State of New York—Department of Agriculture

THIRTY-THIRD ANNUAL REPORT

OF THE

New York Agricultural Experiment Station

(GENEVA, ONTARIO COUNTY)

FOR THE YEAR 1914

With Reports of Director and Other Officers

TRANSMITTED TO THE LEGISLATURE JANUARY 15, 1915

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STATE OF NEW YORK

No. 21.

IN SENATE

January 15, 1915.

THIRTY-THIRD ANNUAL REPORT

OF THE

BOARD OF CONTROL OF THE NEW YORK AGRICULTURAL EXPERIMENT STATION

STATE OF NEW YORK:

Department of Agriculture,

Albany, *January* 15, 1915.

To the Legislature of the State of New York:

I have the honor to submit herewith the Thirty-third Annual Report of the Director and Board of Control of the New York Agricultural Experiment Station at Geneva, N. Y., in pursuance of the provisions of the Agricultural Law.

I am, respectfully yours,

CALVIN J. HUSON,

Commissioner of Agriculture.

NEW YORK AGRICULTURAL EXPERIMENT STATION,

W. H. JORDAN, *Director.*

GENEVA, N. Y., *January* 12, 1915.

Hon. CALVIN J. HUSON, *Commissioner of Agriculture, Albany, N. Y.:*

DEAR SIR: I have the honor to transmit herewith the report of the Director of the New York Agricultural Experiment Station for the year 1914.

Yours respectfully,

BURT E. SMALLEY,

President Board of Control.

BOARD OF CONTROL.

Governor Martin H. Glynn, Albany.

Commissioner Calvin J. Huson, Albany.
Thomas B. Wilson, Hall.
Burt E. Smalley, Interlaken.
[1] G. Hyde Clarke, Cooperstown.
Henry C. Harpending, Dundee.
Eugene M. Andrews, Union.
C. Willard Rice, Geneva.
Adrian Tuttle, Watkins.

OFFICERS OF THE BOARD.

Burt E. Smalley,
President.

William O'Hanlon,
Secretary and Treasurer.

STATION STAFF.

Whitman H. Jordan, Sc.D., LL.D., *Director.*

George W. Churchill,
Agriculturist and Superintendent of Labor.

Joseph F. Barker, M.S.,
Agronomist.

Reginald C. Collison, M.S.,
Associate Agronomist.

Richard F. Keeler, A.B.,
Assistant Chemist (Soils).

[2] Everett P. Reed, B.S.A.,
Assistant Agronomist.

William P. Wheeler,
First Assistant (Animal Industry).

Robert S. Breed, Ph.D.,
Bacteriologist.

Harold J. Conn, Ph.D.,
Associate Bacteriologist.

Godfrey L. A. Ruehle, M.S.,
James D. Brew, B.S.,
Assistant Bacteriologists.

Fred C. Stewart, M.S.,
Botanist.

Walter O. Gloyer, A.M.,
[3] Forest M. Blodgett, Ph.D.,
Associate Botanists.

Mancel T. Munn, B.S.,
Assistant Botanist.

Lucius L. Van Slyke, Ph.D.,
Chemist.

Alfred W. Bosworth, A.M.,
[4] Ernest L. Baker, B.S.,
Rudolph J. Anderson, B.S.,
Associate Chemists.

Arthur W. Clark, B.S.,
Morgan P. Sweeney, A.M.,
Otto McCreary, B.S.,
[5] Allen K. Burke, B.S.,
[6] Clarence D. Parker, B.S.,
[7] Frederick N. Crawford, B.S.,
Assistant Chemists.

George A. Smith, *Dairy Expert.*

Frank H. Hall, B.S.,
Vice-Director; Editor and Librarian.

Percival J. Parrott, M.A.,
Entomologist.

Hugh Glasgow, Ph.D.,
[8] Fred Z. Hartzell, M.A. (Fredonia),
Associate Entomologists.

Harold E. Hodgkiss, B.S.,
Bentley B. Fulton, B.A.,
Assistant Entomologists.

Ulysses P. Hedrick, Sc.D.,
Horticulturist.

Roy D. Anthony, M.S.A.,
[8] Fred E. Gladwin, B.S. (Fredonia),
Associate Horticulturists.

George H. Howe, B.S.A.,
Charles B. Tubergen, B.S.,
Joseph W. Wellington, B.S.,
Assistant Horticulturists.

[9] Carl C. Carstens, B.S.,
Student Assistant.

Orrin M. Taylor,
Foreman in Horticulture.

[10] F. Atwood Sirrine, M.S.,
Special Agent.

Jessie A. Sperry,
Director's Secretary.

Frank E. Newton,
Willard F. Patchin,
Lena G. Curtis,
Agnes E. Ryan,
Esther F. Hawkins,
Clerks and Stenographers.

Adin H. Horton,
Computer and Mailing Clerk.

Address all correspondence, not to individual members of the staff, but to the New York Agricultural Experiment Station, Geneva, N. Y.

The Bulletins published by the Station will be sent free to any farmer applying for them.

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[1] Deceased.
[2] Appointed July 17.
[3] Connected with Hop Culture Investigations.
[4] Resigned March 26.
[5] Resigned December 5.
[6] Appointed February 7; resigned November 15.
[7] Appointed May 1.
[8] Connected with Grape Culture Investigations.
[9] From June 1.
[10] Riverhead, N. Y.

TABLE OF CONTENTS.

Thirty-third Annual Report

OF THE

Board of Control of the New York Agricultural Experiment Station

TREASURER'S REPORT

Geneva, N. Y., *October* 1, 1914.

To the Board of Control of the New York Agricultural Experiment Station:

As Treasurer of the Board of Control, I respectfully submit the following report for the fiscal year ending September 30, 1914:

Maintenance Fund — Necessary Expenses.

appropriation 1913–1914.

1913.	*Receipts.*	*Dr.*
Oct. 1.	To balance on hand	$5,004 26
	To amount received from Comptroller..	24,000 00
		$29,004 26

Expenditures.	*Cr.*
By building and repairs	$231 54
By chemical supplies	1,576 21
By contingent expenses	3,311 30
By feeding stuffs	2,307 00
By fertilizers.	760 39
By freight and express	1,219 25
By furniture and fixtures	681 33
By heat, light and water.	1,053 33
By rent of land	84 00
By library	1,652 71
By live stock	8 00
By postage and stationery	2,926 41
By publications.	1,186 01
By scientific apparatus	2,978 71
By seeds, plants and sundry supplies. . .	5,436 45
By tools, implements and machinery. . .	627 71
By traveling expenses	2,874 11
By balance.	89 80
	$29,004 26

GENERAL EXPENSE — HEAT, LIGHT, WATER, APPARATUS, REPAIRS, ETC.

1913.		*Receipts.*	*Dr.*
Oct.	1.	To balance on hand	$11 29
		To amount received from Comptroller. .	5,500 00
			$5,511 29

	Expenditures.	*Cr.*
	By building and repairs	$2,089 44
	By heat, light and water.............	3,323 45
	By tools, implements and machinery...	95 33
	By balance........................	3 07
		$5,511 29

Salaries.

1913.	*Receipts.*	*Dr.*
Oct. 1.	To balance on hand	$4,285 72
	To amount received from Comptroller..	52,000 00
		$56,285 72

	Expenditures.	*Cr.*
	By salaries	$51,531 79
	By balance..........................	4,753 93
		$56,285 72

Labor.

1913.	*Receipts.*	*Dr.*
Oct. 1.	To balance on hand	$826 98
	To amount received from Comptroller..	16,000 00
		$16,826 98

	Expenditures.	*Cr.*
	By labor	$16,055 23
	By balance.........................	771 75
		$16,826 98

CONCENTRATED FEEDING STUFFS INSPECTION.

1913.		*Receipts.*	*Dr.*
Oct.	1.	To balance on hand	$1,771 88
		Expenditures.	*Cr.*
		By chemical supplies	$104 75
		By contingent expenses	50
		By freight and express	22 79
		By heat, light and water	69 00
		By labor	17 39
		By salaries	1,489 84
		By scientific apparatus	7 50
		By tools, implements and machinery	17 50
		By traveling expenses	42 61
			$1,771 88

FERTILIZER INSPECTION.

1913.		*Receipts.*	*Dr.*
Oct.	1.	To balance on hand	$4,096 54
		Expenditures.	*Cr.*
		By chemical supplies	$302 27
		By freight and express	111 32
		By heat, light and water	261 80
		By labor	633 06
		By postage and stationery	29 26
		By salaries	2,530 63
		By scientific apparatus	228 20
			$4,096 54

FERTILIZERS, FEEDING STUFFS, ETC.

1913.		*Receipts.*	*Dr.*
Oct.	1.	To amount received from Comptroller	$8,696 45

Expenditures.	*Cr.*
By chemical supplies	$1,057 10
By contingent expenses	25
By freight and express	4 28
By heat, light and water	201 50
By labor	1,875 90
By salaries	4,794 87
By scientific apparatus	725 57
By seeds, plants and sundry supplies	2 38
By traveling expenses	34 60
	$8,696 45

Investigation of Grapes.

1913.	*Receipts.*	*Dr.*
Oct. 1.	To amount received from Comptroller	$7,554 09

Expenditures.	*Cr.*
By chemical supplies	$17 61
By contingent expenses	1,254 30
By fertilizers	315 71
By freight and express	37 97
By furniture and fixtures	47 00
By heat, light and water	19 52
By labor	793 46
By library	2 56
By postage and stationery	67 10
By salaries	3,969 71
By scientific apparatus	64 08
By seeds, plants and sundry supplies	540 69
By tools, implements and machinery	96 95
By traveling expenses	327 43
	$7,554 09

INVESTIGATION OF HOPS.

1913.	*Receipts.*	*Dr.*
Oct. 1.	To amount received from Comptroller..	$1,301 44

	Expenditures.	*Cr.*
	By chemical supplies	$2 62
	By contingent expenses	40 19
	By fertilizers	61 14
	By freight and express..............	22 90
	By furniture and fixtures	5 85
	By postage and stationery...........	1 30
	By salaries	683 25
	By seeds, plants and sundry supplies...	42 07
	By tools, implements and machinery...	276 11
	By traveling expenses	166 01
		$1,301 44

REPAIRS TO CHEMICAL LABORATORY.

1913.	*Receipts.*	*Dr.*
Oct. 1.	To amount received from Comptroller..	$1,290 33

	Expenditures.	*Cr.*
	By equipment	$763 00
	By building and repairs.............	527 33
		$1,290 33

NEW BUILDINGS.

1913.	*Receipts.*	*Dr.*
Oct. 1.	To amount received from Comptroller..	$411 53

	Expenditures.	*Cr.*
	By equipment	$411 53

FIELD, ORCHARD AND MILK INVESTIGATIONS.

1913.	*Receipts.*	*Dr.*	
Oct. 1.	To amount received from Comptroller..	$13,717	15
	Expenditures.	*Cr.*	
	By chemical supplies	$12	22
	By contingent expenses	862	09
	By fertilizers	282	89
	By freight and express...............	29	16
	By labor	2,117	69
	By postage and stationery............	4	17
	By salaries..........................	7,580	02
	By scientific apparatus	65	21
	By seeds, plants and sundry supplies...	2,163	46
	By tools, implements and machinery...	60	00
	By traveling expenses	540	24
		$13,717	15

UNITED STATES APPROPRIATIONS.

HATCH FUND.

Receipts 1913–1914.	*Dr.*	
To receipts from the Treasurer of the United States as per appropriation for fiscal year ended June 30, 1914, as per act of Congress approved March 2, 1887	$1,500	00
Expenditures.	*Cr.*	
By building and repairs..............	$56	28
By chemical supplies		79
By contingent expenses	222	50
By labor.............................	697	45
By library	45	85
By scientific apparatus	262	72
By tools, implements and machinery...	214	05
By balance...........................		36
	$1,500	00

ADAMS FUND.

Receipts 1913–1914.	*Dr.*
To receipts from the Treasurer of the United States as per appropriation for fiscal year ended June 30, 1914, as per act of Congress approved March 2, 1887	$1,500 00

Expenditures.	*Cr.*
By salaries	$1,499 96
By balance	04
	$1,500 00

RING MEMORIAL FUND.

Receipts.	*Dr.*
Aug. 1, 1914	$1,000 00

1914.	*Cr.*
Oct. 1. By balance	$1,000 00

I have received and remitted to the State Treasurer for the fiscal year ending October 1, 1914, for produce sold	$1,855 77

All expenditures are supported by vouchers approved by the Auditing Committee of the Board of Control and have been forwarded to the Comptroller of the State of New York.

WILLIAM O'HANLON,
Treasurer.

DIRECTOR'S REPORT FOR 1914.*

To the Honorable Board of Control of the New York Agricultural Experiment Station:

Gentlemen.— I respectfully submit herewith the report of the operations of this institution for the calendar year 1914, together with a statement of our needs for maintenance and for additional equipment. The past year has not been marked by any unusual development in the work of the Station. The work of the various departments has proceeded along the usual lines. Doubtless our constituency has already learned that the development of knowledge and of its application to practical affairs is accomplished with great slowness if the conclusions reached are to be sound and calculated to stand the test of experience. It is fair to say, however, that the institution has made progress both in its equipment and in its studies in matters important to agriculture.

ADMINISTRATION.

STATION STAFF.

The usual number of changes have occurred in the Station Staff. Mr. E. L. Baker, Associate Chemist, who had been with the institution since May 8, 1905, resigned in April to accept a commercial position. This change was greatly to his financial advantage and the situation could not reasonably be met by the institution. Mr. Baker had had immediate charge for some time of the inspection of fertilizers and feeding stuffs and had occupied that position with satisfaction both to the institution and to the constituency which he served.

Mr. A. K. Burke, B.S., a graduate of the University of Maine, who had had previous experience in experiment station work, served the institution during a portion of 1913, and after an absence

* Reprint of Bulletin No. 393, December, 1914.

was reinstated in March. He resigned this position in December to accept a commercial opportunity, much to my regret, as he had shown himself to be an efficient analytical chemist.

Mr. F. N. Crawford, A.B., was appointed Assistant Chemist on May first. Mr. Crawford is a graduate of Wesleyan University, Middletown, Conn., and had had previous experience in experiment station work at the Pennsylvania State College.

Mr. C. D. Parker, B.S., graduate of Cornell University, accepted a position of Assistant Chemist in February, and in November received an appointment in the United States Geological Survey.

Mr. Everett P. Reed, B.S.A., a graduate of Ohio State University, entered upon the duties of Assistant Agronomist in July.

METHOD OF APPOINTING MEMBERS OF SCIENTIFIC STAFF.

With the exception of the Associate and Assistant Chemists, the members of the scientific staff of the Station are classified in the non-competitive civil service list and are subject to appointment under the regulations applying to non-competitive positions. This is a very fortunate arrangement for the institution. Moreover, appointments are not restricted to residents of the State of New York. This is not only a fortunate regulation but one essential to the greatest efficiency in investigation. A scientific institution should not have placed upon it any limitations that prevent the securing of men of the highest possible grade. In view of the fact that similar institutions outside of New York State draw freely upon the staff of this institution for appointments to more advanced positions, the New York Station should have the privilege of selection from men of the whole country. Indeed, the number of men who have been efficiently trained for scientific investigation along agricultural lines is so limited that any restrictions whatever on the opportunity to secure well-trained men would be a serious handicap. Besides all this, no civil service scheme has yet been devised whereby men may be wisely selected by competitive examination for scientific positions. The management of the Station appreciates very highly the wisdom of the Civil Service Commission in authorizing the arrangement that exists. It is to be hoped that the time will come when the Associate and Assistant Chemists will also be placed in the non-competitive list.

MAINTENANCE FUND.

The legislative appropriations for the maintenance of the Station during the fiscal year ending September 30, 1914, were as follows:

Salaries	$52,000
Labor	16,000
For meeting the general expense of the Station departments	24,000
General expenses including heat, light, water, repairs, etc	5,500
For special grape investigations	7,500
For field, orchard and sanitary milk investigations	15,500
For special investigation in hop culture	5,000
Total	$125,500

For the analyses of samples of fertilizers, feeding stuffs, fungicides, insecticides and agricultural seeds submitted by the State Commissioner of Agriculture, and for the examination of Babcock glassware	$16,000

The following are the appropriations available for the current fiscal year:

Salaries for scientific staff	$52,000
Labor	17,000
Necessary expenses of Station departments	23,000
General expense including heat, light and water	5,500
Investigations in grape culture	7,500
For field, orchard, truck, garden crops and sanitary milk investigations	14,500
Repairs, Dairy and Biological Building and forcing houses	1,500
Total	$121,000

For the analyses of samples of fertilizers, feeding stuffs, fungicides, insecticides and agricultural seeds submitted by the State Commissioner of Agriculture, and for the examination of Babcock glassware	$16,000

The appropriations which your Board has requested from the Legislature for the fiscal year beginning October 1, 1914, are as follows:

General salaries of members of scientific and clerical staffs	$56,560
Necessary expenses of investigations, excluding salaries, but including chemicals, scientific apparatus, machinery, fertilizers, cattle foods, maintenance of working animals, traveling expenses and other necessary expenses, in conducting researches at the institution, and throughout the State in soils, plant nutrition, horticulture, diseases of plants, injurious insects, bacteriology, animal nutrition, dairy practice and poultry keeping	23,000
Services of laborers, including janitors, poultryman, engineer, herdsman, dairy helper, foreman of orchards, florist and gardener, general mechanic, watchman, teamsters, farm and other common labor	18,340
General expenses, including heat, light, water, general equipment and general repairs	5,500

Investigations of the conditions of grape growing in Chautauqua County and other grape-growing sections of the State, including cultivation, methods of management, fungus and insect depredations and varieties:

Salaries	$3,800
Labor and general expenses	3,700
Total	$7,500

For conducting field, orchard and truck and garden crop investigations and demonstrations and investigating and demonstrating the means and methods of producing sanitary milk:

Salaries	$10,400
Labor and general expenses	4,500
Total	$14,900

For the enforcing of the provisions of the law in relation to commercial fertilizers, concentrated feeding stuffs, fungicides and insecticides, agricultural seeds and the testing and marking of Babcock glassware, pursuant to sections two hundred and twenty-four, one hundred and sixty-four and one hundred and forty-three of chapter nine of the laws of nineteen hundred and nine, section thirty-four and section fifteen, chapter two hundred and ninety-seven of the laws of nineteen hundred and twelve:

Salaries	$13,570
For general expenses	2,700
Total	$16,270
Grand total for maintenace	$142,070

The budget as given above is in the one filed with the Commission of Efficiency and Economy and the Comptroller's office, excepting that in all cases outside of common labor the salaries of the various positions in the scientific, clerical and labor staffs are individualized.

The appropriations requested for the fiscal year 1915–16, are in total $5,000 more than the appropriations that were made for the fiscal year 1914–15. This is due to the fact that previous to January 1, 1914, the proceeds from the farm were directly applied to Station expenses. Since January 1, 1914, all farm products have been turned into cash and the proceeds forwarded to the Comptroller's office. The amount of such proceeds is not far from $4,000 per year.

For various reasons, I have in addition submitted a substitute schedule of expenses consisting of but four items, as follows:

SALARIES OF SCIENTIFIC AND CLERICAL FORCE.

For the payment of the salaries of director, agronomists, bacteriologists, botanists, chemists, dairy experts, editor and librarian, entomologists, horticulturists, field agents, stenographers, clerks and other scientific and clerical help necessary to the carrying out of the purposes of the institution through investigations and experiments at the institution and throughout the State	$70,000

Services of Laborers.

For the payment of labor, including janitors, poultryman, engineer, herdsman, dairy helper, foreman of orchards, florist and gardener, general mechanic, watchman, teamsters, farm and other common labor........	$20,000

Expenses of Investigations.

For necessary expenses, excluding salaries and labor, but including chemicals, scientific apparatus, machinery, fertilizers, cattle foods, traveling expenses, maintenance of farm teams, heat, light, water, general repairs, general equipment, care of grounds and other expenses necessary to maintaining the institution and to conducting researches and experiments at the institution and throughout the State in soils, plant nutrition, horticulture, diseases of plants, injurious insects, bacteriology, animal nutrition, dairy practice and poultry keeping, including special investigations in the conditions of grape growing, hop growing, the production of orchard, truck and garden crops and the means and methods of sanitary milk production..	36,000

Inspection of Fertilizers, Feeding Stuffs, et cetera.

For the New York State Agricultural Experiment Station for enforcing the provisions of the law in relation to commercial fertilizers, concentrated feeding stuffs, fungicides and insecticides, agricultural seeds and the testing and marking of Babcock glassware, pursuant to sections two hundred and twenty-four, one hundred and sixty-four and one hundred and forty-three of chapter nine of the laws of nineteen hundred and nine, section thirty-four and section fifteen, chapter two hundred and ninety-seven of the laws of nineteen hundred and twelve, for the payment of salaries of chemists, botanists and laboratory assistants...............	12,070
For janitor service and other labor.................................	1,500
For the purchase of scientific apparatus, chemical and laboratory supplies, expressage, traveling expenses and other necessary expenses...........	2,700
Grand total for maintenance..................................	$142,270

It is especially important that the amount necessary for salaries should be appropriated in a lump sum. Up to the fiscal year 1914-15, during the thirty or more years of existence of the Station, salaries have not been individualized, and there has been no intimation that the lump-sum method of appropriation has been in any way abused. As a matter of fact, a list of salaried positions with the salaries paid has been for several years annually filed in the Comptroller's office and this information has been at all times available to the Legislature.

There are some serious objections to the individualizing of salaries under the conditions which prevail at an institution of this character.

It is not possible to wisely state the salaried positions and salaries which should be paid in an institution of investigation with our

varied work and shifting problems one year in advance of the time at which the money is to be used. Again, with fixed salaries for fixed positions, we are unable to exercise discretion in retaining a man when he is called to another institution and it is wise to increase his salary to hold him. In fact, the whole system is so fixed and mechanical that it very seriously limits the autonomy of the institution in handling its salary fund in an efficient and adaptable manner. No more money is spent under the lump sum than under the individualized salary plan. It is simply a question of giving the authorities of the institution the opportunity to exercise judgment in the application of these funds to the work of the institution.

The labor item includes not only the labor necessary at this Station but also in various localities outside in the State for carrying on the experimental work in hand and is therefore an increase of about $3,000 over the labor item for 1914–15, which did not include outside labor. In the past our labor appropriations have been more scanty in proportion to the need than any other appropriation.

The expense of investigations and maintenance of the institution should be lumped because the general expenses of the institution are related to all our work. The whole purpose of the institution is investigation and it simplifies bookkeeping and renders more elastic and efficient the application of the funds where they may be adjusted from year to year to somewhat varying distribution of funds among the various objects.

In general, it may be said because of more or less interchangeability of men between various lines of work, because of the changes necessary to adapt the work to the problems which come to us and because of the relation of expense to all of our work, it is simpler and more rational to appropriate to the institution in those lump sums rather than in a mechanical division which is often embarrassing and which greatly adds to the work of administration of funds.

NEW EQUIPMENT.

The Experiment Station was established in 1882, and since that time it has been growing slowly but continuously. This growth has not been forced but has been the result of demands made by agricultural people for the solution of important problems. During the eighteen years in which I have been connected with the institution, the scientific and clerical staff has increased from fourteen

persons to approximately forty. The building equipment has also increased, but not at all in proportion to the demands made upon the Station. For several years an effort has been made to secure a building which would serve at the same time to accommodate the administrative offices, give space for the visualizing of results which we have reached and provide an auditorium. During this time other needs have become very apparent and by direction of your Board what may seem to many a liberal sum of money is now being asked for additional equipment. The coming Legislature is to be asked for appropriations for three buildings — an administration, demonstration and library building, new forcing houses and a building providing cold storage facilities.

The reasons why we ask for the larger building have been stated many times, but are here again summarized:

The Station has no audience room where agricultural societies and other bodies of farmers may meet for the discussion of our work. During the summer season, large bodies of farmers come to the Station and in case of rain (which frequently occurs) it is not possible for an audience to assemble. More visitations would be made if we had an audience room. Agricultural societies would meet with us if an audience room was available. No other agricultural institution, of which I know is placed in so awkward a situation.

At least three existing departments of the Station need more space and the new department for the investigation of soils must be provided with quarters much larger that it now possesses. The new building would relieve space in two other buildings in order to give needed rooms for the department mentioned.

The Station is seriously in need of a generous amount of space, not now provided, for setting up objective demonstrations of its work in dairying, plant diseases, injurious insects, horticulture, fertilizers and feeding stuffs in order that the visitors, who come to us by hundreds, may gain an intelligent idea of what the Station has done. Such demonstrations are also needed if agricultural bodies are to meet with us.

The Station has now come to possess a valuable library of several thousand volumes, and space in fireproof quarters should be provided for this library. It is now located in the old mansion house bought with the Station farm.

The old mansion house, now occupied by the administrative offices and library, is needed as a place where the members of the staff and other employees can get meals, and where living rooms can be furnished to those persons who should be on the Station grounds. The Station is a mile and a half from the city where board can be obtained and it is time-consuming and wasteful for members of the Station staff to travel so far in order to get a midday meal. It is important that such accommodations exist as the mansion house would furnish if the administrative offices and library could be moved into another building.

In the thirty years' existence of the Station, there has been appropriated to it for buildings in all only $155,450. Twenty-seven buildings now exist on the Station property, and it is fair to claim that no other State institution has a better record for economy of expenditure in the way of building equipment.

The time has come when in order to carry on its work with the desired efficiency new and greatly enlarged plant houses should be provided. The present plant houses of the Station were erected about twenty-five years ago. They have exceeded the usual life of such structures, and are now neither adequate nor efficient. There is a large amount of work in agricultural investigation which should be carried on in such houses, if carried on at all, and includes plant breeding, plant nutrition and studies of plant diseases and injurious insects, to all of which lines the Station is obliged to give much attention.

The small cold-storage house, established chiefly for the storing of fruits, was erected at the Station something more than twenty years ago. The preservation of fruits, of which the Station has several thousand varieties, requires cold storage facilities in order that such materials may be used for study and exhibition purposes. The present cold-storage plant is inadequate in size and construction and if retained will need enlargement and extensive repairs. A new building should be erected.

PUBLICATIONS.

The publications of the Station during the year 1914 consist of 21 regular bulletins, 8 technical bulletins and 7 circulars. Of the regular or complete bulletins, 14 have been popularized in a brief

and more condensed form. The number of bulletins issued from each of the departments of the institution has been as follows:

	Agronomy.	Bacteriology.	Botany.	Chemistry.	Entomology.	Horticulture.	Inspection.
Complete bulletins.	......	2	3	......	4	6	5
Technical bulletins.	......	2	......	6	......	......	......
Circulars.........	2	......	......	......	1	4	......

These bulletins are issued chiefly to residents of New York. So far no reasonable requests to have bulletins sent to residents of other States have been denied. The number of names of residents of other States now on our mailing list approaches 2,500, and as this institution is supported very largely by State funds it may at no distant date become necessary to consider whether residents of other States should not be required to pay at least the cost of publication of the bulletins they desire from this institution. The number of names now on our mailing list with their distribution is as follows:

Popular Bulletins.

Residents of New York	37,330
Residents of other States	2,309
Newspapers	750
Experiment stations and their staffs	2,210
Miscellaneous	100
Total	42,699

Complete Bulletins.

Experiment stations and their staffs	2,210
Libraries, scientists, etc.	330
Foreign list	344
Individuals	3,652
Miscellaneous	100
Total	6,636

There will be presented to the Legislature for publication the manuscript of a volume to be known as the "Cherries of New York," which will constitute Part 2 of the Report of the Station for 1914. This is the fourth fruit monograph. A fifth volume is now under preparation, to be known as the "Peaches of New York," which

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latter will doubtless be presented for publication in the report either for 1915 or 1916. It is quite probable that in time other volumes of similar character will follow.

As was stated in the last report, the Legislature of 1913 authorized the printing of an edition of five thousand copies of the " Apples of New York " to be sold at cost, not only to residents of the State but to anyone making application and paying the required sum. The cost of publication has been set at $2.25 per set of two volumes and already a large number of copies have been sold. Application for the " Apples of New York " should now be made to the Commissioner of Agriculture, Albany, N. Y.; and checks or other means of payment should be drawn in favor of the Treasurer of the State of New York.

INSPECTION WORK.

The chemical work involved in the analysis of samples of fertilizers, feeding stuffs, fungicides and insecticides collected by the Commissioner of Agriculture and forwarded to this institution in accordance with the requirements of law has reached large proportions. The examination of the samples of agricultural seeds received from the same source now consumes a large amount of time. Besides this the law requires that all Babcock glassware that is used in New York by creameries and cheese factories which purchase milk on the basis of the fat content shall be tested for accuracy and marked by the Experiment Station.

Following is a summary of the work performed by the Station along these lines during the year 1914:

Fertilizers	1,004 samples
Feeding stuffs	604 samples
Agricultural seeds, official	302 samples
Agricultural seeds, from farmers	1,155 samples
Total	3,065 samples

Milk bottles	23,104
Cream bottles	6,591
Pipettes	452
Total	30,147

INVESTIGATIONS RELATIVE TO HOP CULTURE.

For two years the Experiment Station has been carrying on investigations relative to the control of mildew on hops, in the hop-growing

region in Otsego County and vicinity. The results show that a good degree of control of this hop pest is secured by a thorough dusting with sulphur. It now remains for the hop growers to apply the remedy and it is not felt that it is wise to make further expenditure of money along this line. Practically no work has been done on the culture of the hop and for that reason a new field has been started on the farm of P. R. Bennett, of Milford, where experiments in methods of culture and fertilization will be carried on. It is felt that by starting a new field the results of the experiments will be more significant than if these experiments are carried on in an old field.

INVESTIGATIONS RELATIVE TO GRAPE CULTURE.

The studies which are being carried on in Chautauqua County, largely in the vineyard rented of Mr. H. B. Benjamin, which will be continued for at least ten years, have already produced fruitful results. Experiments are also being conducted in the control of insect and fungus pests in various places in Chautauqua County, and the outcome of this work is very encouraging. As intimated in my last report, similar work has been taken up in the Keuka Lake region at Urbana. As the experiments in this locality have only been carried on for one year, nothing of any definite character can be said concerning the outcome.

INVESTIGATIONS RELATIVE TO TOBACCO CULTURE.

The fertilizer experiments located with the Minier Brothers at Big Flats have been discontinued and the results will be published at the earliest opportunity. Experimental work is being continued at Baldwinsville in cooperation with the United States Department of Agriculture, Mr. George W. Harris, representing the Department, having the immediate supervision of the work.

SOIL INVESTIGATIONS.

The equipment of the Department of Agronomy for reliable investigation of soils has been greatly augmented by the construction of a battery of lysimeter tanks by means of which it will be possible to study certain soil problems in a much more exact manner than could be done in field work. Studies with such an apparatus must be continued for a long time before conclusions are reached.

It is well to bear in mind that while field experiments for the purpose of studying fertilizer needs, methods of culture and so on are useful, they very seldom and perhaps never answer any fundamental questions. Such experiments must be regarded as tests of business methods. They do not generally furnish information which is useful for general application, as the results have at the best only a regional applicability. As a matter of fact, each farm is an individual business proposition and the methods of culture and of fertilization should be adapted to it in accordance with conditions which may be unlike those of any other farm. What we should seek for are general principles which may be incorporated into farm practice according to prevailing conditions.

EXPERIMENTAL WORK CONDUCTED OUTSIDE OF THE STATION LABORATORIES AND GROUNDS.

There are many lines of investigation and experimental effort where the conclusions reached are of general application. This is particularly true of conclusions concerning the control of injurious insects and fungus pests. It is fair to conclude that any method which proves efficacious in controlling apple scab in Ontario County will have practically equal value in Niagara County. The same may be said of the use of an insecticide. There do not enter into experimental work of this kind, conditions as complex or as indefinite as is the case with cultural or fertilizer experiments.

The experimental work which the Station is carrying on in various parts of the State should not be regarded as mere demonstrations. While it partakes of this character in a certain sense, such work is instituted primarily for the purpose of acquiring information. It is fortunate, however, that it may also furnish object lessons to those farmers or others who take the trouble to observe it carefully.

During 1914 the Experiment Station has carried on experimental work of various kinds touching 30 problems with 109 cooperators on as many farms in various parts of the State. Below may be seen a statement of the subjects under investigation with the name of the cooperator and the location of the experimental work. Not only the Station but the farmers of the State are under obligation to these cooperators for the opportunity given to the Station for studying important problems.

Department of Agronomy.

Alfalfa culture on Volusia soils....	L. Gallager ($\frac{1}{2}$ acre)........	Oxford.
Alfalfa culture on Volusia soils....	C. G. Baker (1 acre).......	Chenango Forks.
Alfalfa culture on Volusia soils....	H. G. Skinner, Jr. ($\frac{1}{2}$ acre)..	Prattsburg.
Alfalfa culture on Volusia soils....	A. S. Matherny ($\frac{1}{2}$ acre)....	Binghamton.
Alfalfa culture on Volusia soils....	L. W. Rorapaugh ($\frac{1}{2}$ acre)..	Cortland.
Alfalfa culture on Voldsia soils....	H. W. Cornell ($\frac{1}{2}$ acre).....	Elmira.
Alfalfa culture on Volusia soils....	F. A. Wigsten ($\frac{1}{2}$ acre).....	Elmira.
Alfalfa culture on Volusia soils....	F. D. Swezey ($\frac{1}{2}$ acre).....	Sherman.
Alfalfa culture on Volusia soils....	J. S. Carnes ($\frac{1}{2}$ acre).......	Great Valley.
Alfalfa culture on Volusia soils....	F. C. Gibbs ($\frac{1}{2}$ acre).......	Fillmore.
Alfalfa culture on Volusia soils....	H. B. Adams ($\frac{1}{2}$ acre)......	Wellsville.
Alfalfa culture on Volusia soils....	General Lyon ($\frac{1}{2}$ acre).....	Binghamton.
Alfalfa culture on Volusia soils....	L. E. Hooker ($\frac{1}{2}$ acre)......	Portville.
Alfalfa culture on Volusia soils....	F. D. Rice ($\frac{1}{2}$ acre)........	Homer.
Alfalfa culture on Volusia soils...	W. P. Mead & Son (4 acres)	Jamestown.
Alfalfa culture on Volusia soils....	Bolt & Huey (4 acres).....	Watkins.
Alfalfa culture on Volusia soils....	B. L. Winters (4 acres).....	Smithboro.
Alfalfa culture on Volusia soils....	A. R. Chappel (2 acres)....	Sidney.
Alfalfa culture on Volusia soils...	W. N. Tarbell (1 acre)......	East Freetown.
Apple orchards: Fertilizer, cultivation and cover-crop tests....	Great Bear Springs Co. (8 acres)..................	Fulton.
Apple orchards: Fertilizer, cultivation and cover-crop tests....	R. B. Densmore (8 acres)...	Albion.
Apple nursery: Fertilizer and cultivation tests..............	W. & T. Smith Co. (2 acres)	Geneva.
Cherry orchard: Fertilizer, cultivation and cover-crop tests....	P. F. O'Neil (3 acres)......	Geneva.
Peach orchard: Fertilizer, cultivation and cover-crop tests.....	T. H. King ($3\frac{1}{2}$ acres)......	Trumansburg.
Pear orchard: Fertilizer and cover-crop tests..............	L. L. Morrell (4 acres).....	Kinderhook.
Pear orchard: Cultivation and cover-crop tests...............	Lawrence Howard (3 acres).	Kinderhook.
Vineyards: Fertilizer and deep-plowing tests.................	F. E. Stone (4 acres).......	Fredonia.
Vineyards: Fertilizer and deep-plowing tests.................	D. W. Blood (2 acres)......	Dunkirk.
Vineyard: Tile-drainage experiments......................	D. W. Blood (4 acres)......	Dunkirk.
Tobacco-culture experiments.....	F. A. Tuerk..............	Baldwinsville.
Tobacco-culture experiments.....	F. J. Patchet.............	Baldwinsville.
Hop-culture experiments.........	P. R. Bennett.............	Milford.
Hop-culture experiments.........	Patrick King..............	Cooperstown.

Botanical Department.

Potato spraying experiments.....	E. B. Keyes..............	Rush.
Cause of poor potato stands......	F. A. Sirrine..............	Riverhead.
Spraying currants for the control of cane blight and anthracnose.	J. R. Clarke & Son........	Milton.
Control of hop mildew...........	W. P. King and F. X. King.	Hartwick.
Control of hop mildew...........	Charles Lehman...........	Sharon Springs.
Control of hop mildew...........	Isaac Russel..............	Milford.
Control of hop mildew...........	E. Wilsey.................	Cooperstown.
Control of hop mildew...........	J. Wedderspoon...........	Cooperstown.
Control of hop mildew...........	L. Utter..................	Cherry Valley.
Clematis stem rot...............	Jackson & Perkins Co......	Newark.

ENTOMOLOGICAL DEPARTMENT.

Control of cranberry toad-bug....	Cranberry Growers' Assoc'n.	Riverhead.
Control of pear thrips...........	Ashley and Rockefeller.....	Germantown.
Control of pear thrips...........	A. W. Hover & Bro........	Germantown.
Control of pear thrips...........	Clarence Snyder...........	North Germantown.
Control of pear thrips...........	Spencer Bros..............	Hudson.
Experiments with apple aphides..	John Beckwith............	New Haven.
Experiments with apple aphides..	George Simpson...........	Carlton.
Experiments with apple aphides..	Harris Freeman...........	Albion.
Experiments with apple aphides..	Albert Wood Estate.......	Carlton.
Experiments with apple aphides..	Thomas Mack.............	Holley.
Experiments with apple aphides..	George Smith.............	Lyndonville.
Experiments with apple aphides..	J. Bayne..................	Lyndonville.
Experiments with apple aphides..	A. J. Skinner.............	Knowlesville.
Experiments with apple aphides..	E. J. Kelly...............	North Rose.
Experiments with apple aphides..	J. A. McAuley............	Lockport.
Experiments with apple aphides..	Floyd Cothran............	Lockport.
Experiments with apple aphides..	Richard Taylor...........	Lockport.
Experiments with apple aphides..	W. E. Wiseman...........	Lockport.
Experiments with apple aphides..	Fred Zimmerman..........	Lockport.
Experiments with apple aphides..	Ralph E. Heard...........	Lockport.
Experiments with apple aphides..	A. A. Fonner.............	Lockport.
Experiments with apple aphides..	H. J. Treichler............	Sanborn.
Experiments with apple aphides..	H. B. Treichler & Son.....	Sanborn.
Experiments with apple aphides..	A. H. Ernest..............	Lockport.
Experiments on pear psylla......	E. E. Barnum............	Albion.
Experiments on pear psylla......	Frank Gibson.............	Albion.
Experiments on pear psylla......	F. E. Hanlon.............	Medina.
Experiments on pear psylla......	H. E. Wellman............	Kendall.
Experiments on pear psylla......	Frank S. Hayden..........	Wyoming.
Experiments on pear psylla......	Frank Bacon.............	Albion.
Experiments on pear psylla......	F. P. Hazleton............	Le Roy.
Experiments on pear psylla......	S. S. Hopkins.............	Youngstown.
Experiments on pear psylla......	S. W. McCollum..........	Lockport.
Experiments on pear psylla......	E. Moody & Son..........	Lockport.
Experiments on pear psylla......	C. G. & R. L. Oaks........	North Rose.
Experiments on pear psylla......	A. C. Pease...............	Oswego.
Experiments on pear psylla......	Ira Pease.................	Oswego.
Experiments on pear psylla......	R. L. Rogers..............	Albion.
Experiments on pear psylla......	David Smith..............	Middleport.
Experiments on pear psylla......	F. M. Tenny.............	Hilton.
Experiments on pear psylla......	Albert Wood Estate.......	Carlton.
Experiments on pear psylla......	F. M. Woolworth..........	Youngstown.
Experiments on pear psylla......	Lawrence Wright..........	Hilton.
Experiments on pear psylla......	Jay Allis..................	Medina.
Experiments on pear psylla......	Frank Bacon..............	Albion.
Experiments on pear psylla......	Spencer Brownell..........	Oswego.
Experiments on pear psylla......	John Cramer..............	Middleport.
Experiments on pear psylla......	Frank Curtis..............	Hilton.
Experiments on pear psylla......	C. E. Ernest..............	Gasport.
Experiments on pear psylla......	Harris Freeman...........	Albion.
Studies on grape root-worm......	Henry Barnes (5 acres)....	Fredonia.
Studies on grape root-worm......	F. G. Spoden (6 acres).....	Fredonia.
Studies on grape root-worm......	Mrs. C. M. Benjamin (3 acres)..............	Fredonia.
Studies on grape root-worm......	N. G. & G. T. Merritt (4 acres)..............	Sheridan (P. O. Dunkirk.)

ENTOMOLOGICAL DEPARTMENT (*continued*).

Studies on grape root-worm	L. M. Cary (2 acres)	Sheridan (P. O. Dunkirk.)
Studies on grape root-worm	W. E. Skinner (2 acres)	Portland.
Studies on grape root-worm	E. L. Day (3 acres)	Dunkirk.
Studies on grape root-worm	Experiment Vineyard (Sec. 6) (2 acres)	Fredonia.
Studies on grape-berry moth	Mrs. C. M. Benjamin (3 acres)	Fredonia.
Studies on grape-berry moth	D. K. Faldey (6 acres)	Westfield.
Studies on grape-berry moth	Louis Bourne (4 acres)	Westfield.
Studies on rose chafer	Louis Bourne (4 acres)	Westfield.
Studies on rose chafer	O. T. Little (2 acres)	Ripley.

HORTICULTURAL DEPARTMENT.

Comparison of sod mulch and tillage	James Vick's Sons	Elmgrove.
Comparison of sod mulch and tillage	Grant Hitchings	South Onondaga.
Tests of stocks for apples	F. E. Dawley	Fayetteville.
Tests of stocks for apples	Edward van Alstyne	Kinderhook.
Fertilizer, culture and pruning experiments with grapes	H. B. Benjamin	Fredonia.

THE RELATION OF THE STATION TO EXTENSION WORK.

Perhaps the most pronounced effort in the interests of agriculture at the present time is directed toward the extension of knowledge. This effort has more or less overshadowed and to some extent has handicapped efforts for the acquisition of knowledge. While the law establishing this institution explicitly declares that it shall give itself to investigation and experimentation concerning agricultural problems, it has been found necessary to give considerable time and effort to the mere extension of knowledge. This has been done through the attendance of members of the staff upon the meetings of the State agricultural organizations, through work at farmers' institutes, through extensive correspondence in reply to inquiries and through exhibits at the meetings of various societies and at the State Fair. The amount of time that has been required for this work and the extent to which it has interfered with the primary work of the Station has hardly been appreciated outside of the Station staff. Doubtless these extension efforts have been productive of good results. No one who appreciates the relations of an experiment station would desire to have it isolated and fail to have a sympathetic touch with its constituents. On the other hand, scientific investigation, to be successfully carried on, must have the continuous unbroken attention of those who are attempting

to carry it on. It demands a concentration and momentum of mind which should be applied with unbroken continuity.

It is recognized, of course, that through some agencies the knowledge acquired through investigation should reach the people in an available form. It is clear, however, that the same body of men in an experiment station cannot be both investigators and extension teachers, and it seems equally clear that the extension work should be carried on through the agricultural teaching agencies of the State. It now appears as if the organization and funds provided through recent federal legislation, namely the Lever-Smith bill, would tend to relieve the experiment stations of some of the extension work which they have felt obliged to do and would allow a fuller concentration upon the work of inquiry. One of the problems which this institution is now called upon to solve is its adjustment to the extension service. Certainly, in some way its conclusions should be freely available to extension teachers. To accomplish this will be greatly in the interest not only of the agricultural public but of the Station itself.

It is certain that the growth of the extension effort, made possible by federal legislation, will greatly increase the demand not only for the knowledge which we already possess but for the study of problems which still remain unsolved. For this reason it is essential that the development of the agencies devoted to investigation and teaching shall proceed symmetrically. A proper balance should be maintained between the effort of investigation and the effort of teaching, both that in colleges and schools and through popular demonstrations. In view of the popularity of the extension effort, investigation seems liable to receive less attention than it should, and those who understand the situation should most insistently urge that funds applied to investigation should meet existing demands as fully as those applied to the various forms of teaching. It is for this reason, therefore, that the management of the Station respectfully urges that the Legislature not only maintain the institution on its existing basis but provide also for such progress in equipment as the enlarging demands make necessary.

INVESTIGATION.

ANIMAL HUSBANDRY.

Developing the Station herd of dairy cows.— The Station is now in possession of a herd of Jersey cows, practically all full-blood and registered, that is highly productive and for nine years has not developed a single case of tuberculosis. There have been some cases of contagious abortion, especially with the heifers, but this trouble has grown less and less and is now not much in evidence.

The development of a sound herd of this type should be a matter of general interest, especially as the foundation stock consisted in part of tuberculous mothers.

Two phases of this matter should be considered:

(1) The maintenance of the animals in health.

(2) The development of highly productive animals.

Between December, 1900, and March, 1901, fifteen out of the twenty-eight animals owned by the Station were found to be tuberculous. At the latter date the herd was separated into sound and unsound animals, these two groups being located in separate stables, each group under the care of its own attendants. This separation continued, with constant supervision of both herds, until May, 1905, when the six remaining unsound animals were killed.

In November, 1905, thirty animals in the herd were tested with tuberculin and no reaction found, and since that time no case of tuberculosis has appeared. It should be borne in mind in this connection that the nine animals in the Millie Darling family now constituting a part of the Station herd are nearly all descendants of daughters of Millie D., dropped after she reacted and during the time she was with the diseased section of the herd after separation in March, 1901. In brief, part of the Station herd had a diseased mother as foundation stock.

The evolution of a sound herd out of one partially diseased and the maintenance of the herd in a condition of health during nine years have been accomplished in a comparatively simple way.

The following have been the essential factors in the process:

(1) In the beginning, separation at once from their mothers of the calves of diseased cows and feeding them on the milk from sound cows or milk that has been pasteurized.

(2) The maintenance of the herd by raising its heifer calves.

(3) Quarantining the herd against outside dairy wastes and animals coming from infected herds. Pasteurized dairy wastes from outside might have been used safely.

It has been intimated that a highly productive herd has been developed. This is shown to be the case by the following statement of averages made up from records of 1906–8 and 1913–14.

Year.	Number of cows.	Number periods of lactation.	Average yield per cow per period of lactation.	Average percentage of fat.	Average annual yield of fat per lactation. period.
			Lbs.	Per ct.	Lbs.
1906–1908	27	63	6,435	5.16	334
1913–1914	23	23	6,546	5.91	387
Carey family, 1913–1914	14	14	6,139	6.01	369
Millie family, 1913–1914	9	9	6,921	5.82	403

The guiding principles in building up this herd have been:

(1) A standard of selection that includes size and vigor as well as productiveness.

(2) The importation of males from a line of vigorous and productive ancestry.

(3) Avoidance of the forcing system in feeding animals used as breeders. Eight pounds of grain has been the maximum daily ration used in this herd.

(4) Retention of the most promising heifers and turning off of the poorest.

BACTERIOLOGICAL DEPARTMENT.

Microscopical investigations of the bacteria and tissue cells in milk.—The use of the microscope as a means of determining milk quality has been advocated for more than three-quarters of a century, but it is only with the recent development of the sanitary control of milk supplies that the microscopical methods of milk examination have become of practical importance to the milk dealer and dairyman. Because of the great need for a simple method of determining quickly the condition of a given sample of milk relative to bacteria and tissue cells the Station has tested out a new method of making such examinations by means of the microscope and has secured

sufficiently favorable results to justify the publication of two preliminary bulletins which are numbered 373 and 380 respectively.

Microscopical examination of milk for bacteria.— Bulletin No. 373 discusses the usefulness of the microscope as a means of determining the number and the general character of the bacteria present. This bulletin likewise gives a comparison between the results secured with the new method and those secured with the older, and more generally used, cultural methods. The new method promises to be of great value as it is scarcely more difficult to carry out than the well known Babcock test for butter-fat and apparently gives fully as accurate and as usable information in the case of raw milk as do the cultural methods. It likewise has a practical advantage over any cultural method in that the results are almost instantly available so that, if desired, the bacterial quality of a given sample of milk can be determined before it is used. Cultural methods of determining milk quality require from several hours to five days before results are available. By the use of the microscope, raw milk can be readily separated into as many as three grades, and the cost of making the test is so small that it should find general use in the hands of milk dealers. They can use it in this way to control the bacterial quality of the milk which they handle as readily as they can control its butter-fat.

Cells in milk derived from the udder.— Bulletin No. 380 gives the results of studies on the tissue cells in milk which have been made by the use of the technique discussed above. These results have a bearing upon some of the problems involved in the control of garget and have been useful in determining the normal condition of milk. It has been shown that the number of cells present in the milk of apparently normal cows is much larger than has been generally supposed, an average of 868,000 cells per cubic centimeter having been found in the milk of 122 supposedly normal cows. Only 59 of these cows gave milk containing less than 500,000 cells per cubic centimenter, the number which has been frequently used as the border line between normal and abnormal milk. Wide fluctuations in numbers occurred both in the milk of the same cow from day to day and in the milk of the various quarters of the same udder. The number of cells in the strippings was invariably higher than that in the milk from the major portion of the milking. A study of the number of cells in the milk and of the bacteria in the udder

of 43 Guernsey cows failed to show the close relationship between infections of the udder with streptococci and the discharge of large numbers of cells which has been claimed by some previous investigators. The contradictory nature of the results obtained make it increasingly probable that the discharge of these cells is not due to a simple cause.

This bulletin likewise reports the results of the studies which are made to determine whether increasing the vacuum used in operating mechanical milkers would have an effect upon the number of cells discharged in the milk. The investigation was made because it has been frequently thought that increased vacuums drew blood from the interior of the udder, or at least caused an increased discharge of cells. A six weeks' test where the vacuum was increased from the normal of 14.5 inches to 19.5 inches failed to show any effect on the cell content of the milk. A comparison between the number of cells in the milk of machine-milked and hand-milked cows in the Station herd showed somewhat fewer cells in the milk of the machine-milked cows.

Bacteria of frozen soil.— Observations made at the Cornell University Experiment Station a few years ago by one of the present members of this Department have been confirmed and extended by work at this Station. The original observation that the number of bacteria in frozen soil is generally larger than in unfrozen soil has been confirmed, and also it has been shown that this increase is not due to the increase in soil moisture in the frozen soil nor to a migration of bacteria to the surface layers from lower depths. This makes it probable that the increase in number is due to an actual growth of bacteria in frozen soil. Further studies on the effect of seasonal changes on bacterial life are needed to explain this fact and to determine its practical value, if any. The work has been reported in Technical Bulletin No. 35.

Cultural media for soil bacteriological work.— One of the most serious handicaps in agricultural bacteriology is lack of precise methods of work. Much of the present technique in soil bacteriology consists of the crude methods characteristic of the earliest stages of the development of a science or of technique taken from other fields of bacteriology and applied to soil work without any careful study of its efficiency in the new field. For these reasons it has been necessary to make an extended study of the cultural methods

in use for determining the number of bacteria present in soils, which has been reported in Technical Bulletin No. 38. The chief immediate value of the work will be to other workers in agricultural bacteriology, but ultimately the use of the new media suggested in this bulletin should give us facts of practical importance in developing or controlling the fertility of the soil.

Other bacteriological studies.— No publications have been made during the year on the study of the barn conditions in relation to the germ content of milk, but a bulletin is in manuscript form and should go to the printer within a month. A bulletin on the lack of relationship between bacterial count and barn scores is in about the same stage. Field studies on the practical application of the microscopical technique have been made during the year both in connection with the Sheffield Farms–Slawson–Decker Co., at Hobart, and locally, but these are not completed as yet.

BOTANICAL DEPARTMENT.

Currant felt-rust and whitepine blister-rust.— These two diseases are caused by the same fungus, *Cronartium ribicola*, in different stages of its life cycle. On account of repeated outbreaks of felt-rust on currants at Geneva unaccompanied, apparently, by the occurrence of blister-rust on pines in the vicinity, it was suspected that, contrary to accepted belief, the fungus may over-winter on currants. Experiments have been made which, it is believed, clear up this matter. Rusted currant plants were transplanted (after the leaves had fallen) into greenhouses and forced into growth during the winter. Since no trace of felt-rust appeared on the new leaves of any of the 500 plants in the experiments, the conclusion has been reached that *C. ribicola* rarely, if ever, over-winters on the currant. The subsequent discovery of two white pine trees affected with blister-rust makes it possible, now, to account for the outbreaks of currant felt-rust at Geneva without assuming that the fungus over-winters on currants. Details of the experiments have been published in Bulletin No. 374.

Seed testing.— During the year 1913, 292 official samples of seed were analyzed. Of these, 51, or 17.5 per ct., were violations of the law; that is, although containing over three per ct. of foreign seeds by count they were not so labeled when exposed for sale. The percentage of violations was somewhat smaller than in 1912 when it

was 20.8 per ct. Analyses were made, also, of 975 unofficial samples sent in by farmers and seed dealers. The analyses were reported in Bulletin No. 378.

Potato-spraying experiments at Rush.— Bulletin No. 379 contains an account of an extensive series of potato-spraying experiments conducted in the vicinity of Rush during the summer of 1913. In each of 66 fields a portion of one row 290.5 feet long was very thoroughly sprayed by hand every two weeks. At digging time the yield of this row was compared with that of an adjacent row which had not received the special spraying. In 47 fields no spraying was done by the owner. In these fields the test was a comparison between very thorough spraying and no spraying. In the other 19 fields more or less spraying was done by the owner. In these, the test was a comparison between very thorough spraying and the kind of spraying done by the owner.

In the 46˙ unsprayed fields the spraying done by the Station increased the average yield by 17.76 bushels per acre and in the 19 sprayed fields by 15.04 bushels per acre.

The season was a very dry one and there was no potato blight.

CHEMICAL DEPARTMENT.

Inspection work.— There have been published analyses of 480 commercial feeding stuffs and 1004 commercial fertilizers. A study of the data relating to fertilizers shows that the number of samples falling seriously below guaranty is small, the average of all analyses showing an excess of plant-food constituents over guaranty. High-grade fertilizers are shown to furnish plant-food constituents at less cost than low-grade fertilizers. Some defects are pointed out in the present fertilizer law, working against the interests of the purchasers of fertilizers, especially in case of unmixed materials containing a high percentage of plant-food.

Studies relating to the chemistry of milk.— During the entire history of this Station, special attention has been given to some phase of dairy chemistry. The recent work has had for its purpose the clearing up of certain points in the chemistry of milk, some of which have a special relation to the use of milk in human nutrition and some of which are intimately connected with the fundamental processes of cheese-making. In the near future a bulletin will be issued bringing together all the chemical facts which have been worked out here and

showing their relation to the chemistry of the process of cheese-making. The publications of the past year treat of the following points: (a) Sodium citrate is often added with favorable results to milk used in feeding infants and invalids in certain diseased conditions, but no satisfactory explanation of the action has been known; it has been known only that sodium citrate delays the curdling action of milk when it is treated with rennet extract (rennin) and forms a curd of softer than normal consistency, the softness increasing with the amount of sodium citrate added until finally no curdling takes place when the citrate is added at the rate of 0.400 gram per 100 cubic centimeters of milk (equal to 1.7 grains of citrate per ounce of milk). Our work shows that at the point at which rennet extract fails to curdle milk we have a chemical change in the casein of the milk, the normal calcium caseinate of the milk being changed into a double salt, calcium-sodium caseinate, a compound which is changed by rennet extract into calcium-sodium paracaseinate and this latter compound, owing to the presence of sodium, is not curdled. (b) The cause of acidity in fresh milk has been attributed to both the casein and phosphates in milk. Our work shows that casein does not have any relation to the acidity of fresh milk but that the acidity is caused chiefly or solely by acid phosphates in solution. In determining the acidity of milk by titration with alkali, the presence of the soluble calcium salts interferes with the accuracy of the work. We find that this difficulty can be overcome by treating the milk with a saturated solution of neutral potassium oxalate (2 cubic centimeters per 100 cubic centimeters of milk) and thus removing the soluble calcium before determining acid with alkali. The acidity as determined by this method is found to be about half that previously reported by other investigators. (c) The phosphorus content of casein has been previously found to be 0.85 per ct., but our work shows former methods to be inaccurate; the true percentage is about 0.71. (d) The action of rennet extract (rennin) in curdling casein to form paracasein is shown to be a process of hydrolysis, one molecule of casein splitting into two molecules of paracasein. (e) There has been controversy over the composition of milk as to what constituents are in true solution. Investigation made here by improved methods shows that (1) sugar, citric acid or citrates, compounds containing chlorine, potassium and sodium are entirely in solution; (2) albumin, inorganic phosphates and compounds of calcium and magnesium are in part

in solution and in part in suspension or colloidal solution; and (3) fat and casein are wholly in suspension or colloidal solution.

ENTOMOLOGICAL DEPARTMENT.

The cranberry toad-bug.— Bulletin No. 377 contains an account of an investigation to determine the cause of a peculiar dying of the new growth of cranberry vines. Previous to this study the trouble was commonly ascribed to diseases known as "cranberry scald" and "cranberry rot." At the initiation of the work it was soon discovered that the causal agent was not a fungus but an insect (*Phylloscelis atra* Germ.) of the family of Fulgoridae. The cranberry appears to be its sole host plant. If the insect attacks the new growth both branch and fruit are killed, but if it feeds on the old wood the berries and branches beyond the feeding point are shriveled and dwarfed. As a result of this injury the yield from certain varieties has been reduced to one-half or one-fourth of a normal crop.

There is but one brood of the insects during the year. The egg is elongate-oval in shape, with a short stalk at one end. The egg-laying period extends from September 1 to the middle of October. Hatching begins on June 25 to 30 of the following summer, and a few may not hatch until early in August. Nymphs usually group together to feed, and may live a long time on the same branch if not disturbed. The insect has five nymphal instars. The first adults appear about the first of August, the males maturing first.

The habits of the insect suggest two methods for the prevention of injuries: Flooding and spraying, which are discussed with considerable detail on the concluding pages of the bulletin.

The cabbage maggot.— The third contribution by this Station to the knowledge of this destructive pest is made in Bulletin No. 382, and deals especially with the activities of the maggot in relation to the growing of early cabbage.

Of the insecticides that are employed to destroy maggots about the roots of the plants, carbolic-acid emulsion has generally been regarded as the most efficient. Tests with the emulsion at recommended strengths have demonstrated that it will prevent the hatching of the eggs and is fatal to the younger stages of the larvæ. It may, however, cause injury to young seedlings and is not a safe remedy for the treatment of plants recently set in the field.

The value of tar pads, or hexagonal tar-paper collars, for the purpose of preventing the adult of the cabbage maggot from placing eggs about the stems of the plants has been previously demonstrated, but, in spite of its effectiveness, this method of protecting cabbage has not been generally adopted by truck growers. The tests herein described show that tar pads will protect early cabbage from the pest at a cost of about $1.40 per thousand plants. Truck growers who are subject to losses by the cabbage maggot are urged to test the tar pads experimentally as a basis for more extensive operations against this pest.

Susceptibility to spraying mixtures of hibernating pear psylla adults and their eggs.— Bulletin No. 387 deals with investigations on the pear psylla to ascertain the susceptibilities of the hibernating adults and their eggs to spray mixtures. Studies of the seasonal history and habits of the insect showed that this pest passes the winter as an adult, or " fly ", and that the creature deposits its eggs in the spring within a short period after its emergence from hibernating quarters.

The practice of clean culture and the removal and destruction of rough bark left the flies with few opportunities of escape from applications of contact mixtures. The best means of killing the flies is spraying during a period of warm weather, preferably in November or December, or during March or early in April. The most satisfactory mixture, from the standpoints of safety to fruit and leaf buds and effectiveness against the insect is three-fourths of a pint of tobacco extract (40 per ct. nicotine) in 100 gallons of water to which are added from three to five pounds of dissolved soap.

Eggs about to hatch and newly emerged nymphs proved also very vulnerable to an application of the lime-sulphur solution. By postponing the dormant treatment for the San Jose scale until the blossom cluster-buds are beginning to separate at the tips, very effective work can be done against the eggs. The lime-sulphur should be used in the proportion of one gallon of the concentrate, 32° B., to eight gallons of water.

Tree crickets injurious to orchard and garden fruits.— Bulletin No. 388 is a report of studies on various tree crickets, in which attention is directed especially to the more common and injurious species in plantings of garden and tree fruits in the State of New York. One of the most important forms is the snowy tree cricket (*Œcanthus*

niveus De Geer), which oviposits in a great variety of plants. In the region about Geneva eggs are most abundant in apple, plum and cherry, and they are somewhat common in raspberry and walnut. The eggs occur singly in soft, fleshy bark. On raspberry, oviposition takes place in the fleshy area at the side of the bud in the axils of the leaves, and usually there is not more than one egg on each side of a bud. This species subsists on a rather wide assortment of foods of animal and vegetable origin. In addition to other species of insects, microscopical examinations of crop contents have shown that the San Jose scale may, under certain conditions, form a large part of the diet of this cricket. It has also been observed to eat holes in raspberry and apple leaves, and is reputed to attack ripening fruits. This species derives its reputation as an orchard pest chiefly from the occurrence of diseased areas about oviposition wounds in the bark of apple trees. The areas of infection in their external appearances and effects resemble superficially certain stages of the common apple cankers. Cultural and microscopical studies indicate that during 1913 a fungus, *Leptosphaeria coniothyrium* (Fckl.) Sacc., was, in the majority of cases, the infecting organism.

The narrow-winged tree cricket (*Œ. angustipennis* Fitch.) has feeding habits quite similar to the foregoing species, and while common in apple orchards it has also been observed in considerable numbers on alders and scrub and burr oaks. Unlike the preceding species, the striped tree cricket (*Œ. nigricornis* Walker) prefers for the reception of its eggs plants which have a central pith surrounded by a woody outer layer. Among the plants preferred for oviposition are raspberries, which are sometimes seriously damaged. The injuries are due to slitting of the canes as a result of excessive deposition of eggs, which weakens a stalk so that it dies or breaks at the point of the wounded area from the weight of the foliage or as a result of a strong wind.

Tree crickets are amenable to standard orchard operations. Cultivation to destroy foreign vegetation, as weeds and brush in and about plantings of fruit, and to keep the ground about trees and vines clean is an efficient measure for the prevention of damages. While the susceptibility of these insects to arsenicals has not been conclusively demonstrated, it is believed that the numbers of the tree crickets are reduced by summer applications of these poisons. Raspberry canes showing extensive oviposition should be removed

in the course of winter or spring pruning and burned to destroy eggs contained in them.

Cabbage aphis.— This species of aphis, regarded as one of the principal enemies of cabbage, is the subject of Circular No. 30. This is a popular treatise, illustrated with two plates and two text figures, in which the different stages are described and figured and the seasonal history is discussed. The circular closes with a brief discussion of the merits of spraying mixtures and on the selection of a spraying machine for effective work against the pest.

HORTICULTURAL DEPARTMENT.

Tillage and sod mulch in the Hitchings orchard.—For ten years this Station has been comparing sod mulch and tillage in apple orchards. Bulletin No. 375 is a brief account of the experience in the Hitchings orchard, the most notable exception which proves the rule that tillage is the most profitable method for orchard culture under general conditions. From the work in this orchard the following conclusions were reached:

While unquestionably tillage is the best method of caring for the majority of the apple orchards in New York, yet there are particular places, soils and economic conditions under which the Hitchings method of sod-mulching apple trees may be used advantageously:

1st. Orchards on steep hillsides where land would wash badly under tillage may often well be kept in sod.

2nd. On land covered with rocks, trees may best stand in sod.

3rd. The Hitchings method is adapted only to soils having suitable depth. On shallow soils it will usually prove a failure.

4th. Soils must be retentive of moisture. On land that annually suffers from summer droughts the sod-mulch treatment will almost certainly prove less beneficial to trees than tillage.

5th. Economic conditions may decide the choice between tillage and some mulching treatment, since the cost of caring for an orchard is so much less under the Hitchings mode of mulching than by tillage. Thus a larger acreage in sod may be made to counter-balance a greater productiveness under tillage, thereby bringing the net income to the same level.

A comparison of tillage and sod mulch in an apple orchard.— Bulletin No. 383 is the third account of studies by the New York Agricultural Experiment Station to determine whether the apple thrives better

under tillage or in sod. The experiment of which this bulletin is a report was begun in 1903 in the orchard of W. D. Auchter near Rochester, New York. This orchard is far more typical than the Hitchings orchard of the apple-growing regions of New York, in both soil and climate, and the results obtained have much wider adaptability than those set forth in Bulletin No. 375. The conclusions reached were that not only should apples not be grown in sod but that for the best good of the trees there should be no sod near them. Grass militates against apple-growing in sod in several ways which act together, as:

(1) Lowering the water supply.
(2) Decreasing some elements in the food supply.
(3) Reducing the amount of humus.
(4) Lowering the temperature of the soil.
(5) Diminishing the supply of air.
(6) Affecting deleteriously the beneficial micro-flora.
(7) Forming a toxic compound that affects the trees.

Ten years' profits from an apple orchard.— Bulletin No. 376 shows the outgo and the income from an apple orchard for a period of ten years. The orchard was one of Baldwin apples, ten acres in area, situated a few miles west of Rochester, known to many as the Auchter orchard, in which the Geneva Experiment Station has carried on a comparative test of sod mulch and tillage during the last ten years. The average yield of the orchard for the ten years was 79.2 barrels of barrelled stock per acre and 37.6 barrels of evaporator and cider stock. The cost sheet for a barrel of apples was as follows:

Interest on investment	$0.21
Taxes	.012
Tilling	.063
Pruning	.03
Spraying	.096
Cover crop	.023
Superintending orchard	.25
Picking, packing, sorting and hauling	.244
Barrel	.36
	$1.29

The average price received for the apples for the ten years was $2.60 per barrel for all the barrelled stock sold and 72 cents per barrel for the evaporator and cider stock.

The balance sheet is as follows: Subtracting $1.29, the cost of a barrel of apples, from $2.60, the amount received, a net profit of $1.31 per barrel remains for firsts and seconds. Multiplying by 79, the number of barrels per acre, gives $103.49 as the profit per acre for firsts and seconds. Subtracting 72 cents from 93 cents, gives 21 cents as the difference between average cost of production and average selling price of culls. Multiplying 37.6, the number of barrels of culls per acre, by 21, gives a loss of $7.89 per acre on the culls, leaving the average net profit per acre in this orchard for the past ten years $95.60; add to this the $25 interest on the investment and we have $120.60 net, or 24.12 per ct. on $500, as the annual ten-year return from this orchard and the money invested in it.

New or noteworthy fruits.— The New York Agricultural Experiment Station attempts to test all the new varieties of fruit which will grow in New York. The results of this work are published from time to time in the fruit books issued by the Station and in a series of bulletins entitled "New or Noteworthy Fruits." Bulletin No. 385 is the second of the serial reports on these fruit tests. Beside giving an account of several meritorious fruits it contains suggestions to buyers of fruit trees. The following fruits are recommended to fruit growers as worthy of test either for home use or for commercial purposes: King David apple, Edgemont peach, Abbesse D'Oignies cherry, French plum, Hicks grape, Chautauqua gooseberry, Chautauqua currant and the Indiana and Barrymore strawberries.

Distribution of Station apples.— Circular No. 28 describes twelve new varieties of apples for distribution in 1914. These varieties are the outcome of experimental work in plant breeding. They have been grown and compared with practically all of the standard sorts of their kind and are equal or superior in one or more respects to apples of their season, as grown on the Station grounds. The distribution of these varieties is undertaken that their value and adaptability in the different fruit regions of New York may be ascertained. A fuller description of most of the varieties listed has been published in Bulletin No. 350 from this Station.

Culture of sweet corn.— A brief treatise on the culture of sweet corn is given in Circular No. 29, in which the needs of the plant as

to climate, soil and fertilizer are discussed, together with cultural operations and the selection and care of seeds.

Strawberries.— Circular No. 31 discusses the culture of the strawberry. In it may be found a consideration of the following topics having reference to this fruit: Location and soil; preparation of the soil; manures and fertilizers; sex of plants; selection of plants; time of planting; systems of planting; setting the plants; management of the plantation; pests and their control; harvesting and marketing; and a description of the best varieties for New York.

Currants.— The culture of the currant, covering essentially the same topics as those discussed in the circular on the strawberry, is presented in Circular No. 32.

PUBLICATIONS ISSUED DURING 1914.

BULLETINS.

No. 373. February. A comparison of the microscopical method and the plate method of counting bacteria in milk. James D. Brew. Pages 38, colored plates 2, figures 2.

Popular edition (with No. 380), pages 15, colored plates, 2.

No. 374. February. Does *Cronartium ribicola* over-winter on the currant? F. C. Stewart and W. H. Rankin. Pages 15, plates 3, map 1.

Popular edition, pages 4.

No. 375. March. Tillage and sod mulch in the Hitchings orchard. U. P. Hedrick. Pages 28, plates 7.

Popular edition, pages 8.

No. 376. March. Ten years' profits from an apple orchard. U. P. Hedrick. Pages 12, plate 1.

No popular edition issued.

No. 377. March. The cranberry toad-bug. F. A. Sirrine and B. B. Fulton. Pages 24, plates 8, figures 4.

No popular edition issued.

No. 378. March. Seed tests made at the Station during 1913. M. T. Munn. Pages 27.

Popular edition, pages 4.

No. 379. March. Potato-spraying experiments at Rush in 1913. F. C. Stewart. Pages 9.

Popular edition, pages 4.

No. 380. March. Cells in milk derived from the udder. Robert S. Breed. Pages 64.

Popular edition (with No. 373), pages 15, colored plates 2.

No. 381. March. A test of commercial fertilizers for grapes. U. P. Hedrick and F. E. Gladwin. Pages 32, plate 1.

Popular edition, pages 8.

No. 382. April. The cabbage maggot in relation to the growing of early cabbage. W. J. Schoene. Pages 19, plates 6, figures 5.

Popular edition, pages 12, plates 2, figures 5.

No. 383. April. A comparison of tillage and sod mulch in an apple orchard. U. P. Hedrick. Pages 35, plates 6, diagram 1.

Popular edition, pages 7.

No. 384. April. Analyses of materials sold as insecticides and fungicides. Page 22.

No popular edition issued.

No. 385. April. New or noteworthy fruits, II. U. P. Hedrick. Pages 12, colored plates 4.
No popular edition issued.
No. 386. May. Inspection of feeding-stuffs. Pages 72.
No popular edition issued.
No. 387. May. Susceptibility to spraying mixtures of hibernating pear-psylla adults and their eggs. H. E. Hodgkiss. Pages 32, plates 3, figures 2.
Popular edition, pages 10, plates 1, figures 4.
No. 388. May. Tree crickets injurious to orchard and garden fruits. P. J. Parrott and B. B. Fulton. Pages 47, plates 10, figures 9.
Popular edition, pages 8, plates 4, figures 2.
No. 389. July. Dead-arm disease of grapes. Donald Reddick. Pages 30, plates 6, figures 8.
Popular edition, pages 4, plates 2.
No. 390. October. Report of analyses of samples of commercial fertilizers collected by the Commissioner of Agriculture during 1914. Pages 96.
No popular edition issued.
No. 391. December. Ringing fruit trees. G. H. Howe. Pages 12, plate 1.
Popular edition, pages 4.
No. 392. December. Some facts about commercial fertilizers in New York State. L. L. Van Slyke. Pages 43.
Popular edition, pages 8.
No. 393. December. Director's report for 1914. W. H. Jordan. Pages 33.
No popular edition issued.

Technical Bulletins.

No. 32. January. A contribution to the chemistry of phytin. R. J. Anderson. Pages 44.
No. 33. February. Preparation, composition and property of caseinates of magnesium. Lucius L. Van Slyke and Orrin B. Winter. Pages 7.
No. 34. May. I. Why sodium citrate prevents curdling of milk by rennin. Alfred W. Bosworth and Lucius L. Van Slyke. II. The use of sodium citrate for the determination of reverted phosphoric acid. Alfred W. Bosworth. Pages 12.
No. 35. July. Bacteria of frozen soil. H. Joel Conn. Pages 20.
No. 36. July. Organic phosphoric acids of wheat bran. R. J. Anderson.
No. 37. December. Studies relating to the chemistry of milk and casein. Lucius L. Van Slyke and Alfred W. Bosworth. Pages 11.
No. 38. November. Culture media for use in the plate method of counting soil bacteria. H. Joel Conn. Pages 34.
No. 39. December. Condition of casein and salts in milk. Lucius L. Van Slyke and Alfred W. Bosworth. Pages 16.

Circulars.

No. 26. January 12. The use of commercial fertilizers. J. F. Barker. Pages 20.
No. 27. January 20. Ground limestone for soil improvement. J. F. Barker. Pages 14.
No. 28. March 9. Distribution of Station apples. U. P. Hedrick. Pages 3.
No. 29. May 10. Culture of sweet corn. J. W. Wellington. Pages 3.
No. 30. June 15. The cabbage aphis. P. J. Parrott and B. B. Fulton. Pages 4, plates 2, figures 2.
No. 31. November 15. Strawberries. O. M. Taylor. Pages 10.
No. 32. November 20. Currants. O. M. Taylor. Pages 7.

Geneva, N. Y., December 31, 1914.

Respectfully submitted,

W. H. Jordan,

Director.

REPORT

OF THE

Department of Agronomy.

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REPORT OF THE DEPARTMENT OF AGRONOMY.

THE USE OF COMMERCIAL FERTILIZERS.*

J. F. BARKER.

Observations on the popular methods of using commercial fertilizers in this State leave no doubt but that, even at the present time, fertilizing practice is influenced more by the advertising agencies of the various fertilizer concerns than by the results of work at the agricultural experiment stations throughout the country. The fertilizer companies are in close and frequent touch with the farmer by means of elaborate advertisements in farm papers and through their numerous agents, and in this way the farmer has been influenced more than by all the information that has reached him regarding carefully conducted experiments and correct principles of soil management. In this time of many conflicting theories and much unsound teaching on the subject of soil fertility, well grounded facts are refreshing. In these few pages the reader is asked to consider some important facts and their bearing on the practical use of commercial fertilizers.

ELEMENTS REQUIRED FOR PLANT GROWTH.

Ten chemical elements are essential to the growth of all plants. They are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, iron and sulphur. If any one of these elements is entirely lacking plants cannot be grown. In addition, lime carbonate and decaying organic matter are materials necessary to a fertile soil.

Of these ten elements carbon, hydrogen and oxygen are freely furnished by air and water. Iron is supplied in abundance by all soils, and sulphur has scarcely been found to limit crop yields. But the other five elements, nitrogen, phosphorus, potassium, calcium and magnesium, together with lime carbonate and decaying organic matter, are all of vital importance in the practical problem of soil fertility. Certainly every landowner should be on such familiar terms with these materials that he can call them by name and understand fully their relation to his business of farming.

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* Reprint of Circular No. 26, January 12.

The following table shows the approximate amounts of nitrogen, phosphorus, potassium, calcium and magnesium removed per acre annually by good yields of some common farm crops.

TABLE I.—APPROXIMATE AMOUNTS OF CHEMICAL ELEMENTS REMOVED FROM SOIL BY CROPS.

	Nitrogen.	Phosphorus.	Potassium.	Calcium.	Magnesium.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Corn, grain 75 bu...	75	13	15	1	4
Corn, stover 2½ tons.	40	5	42	17	8
Corn crop..........	115	18	57	18	12
Oats, grain 75 bu....	50	8	12	2	3
Oats, straw 2 tons...	25	4	43	12	6
Oat crop...........	75	12	55	14	9
Wheat, grain 40 bu..	56	10	10	1	3
Wheat, straw 2 tons.	20	3	36	8	3
Wheat crop.........	76	13	46	9	6
Timothy hay 3 tons.	72	9	71	42	16
Clover hay 3 tons...	120	15	90	87	23
Alfalfa hay 6 tons...	300	27	145	216	23
Potatoes 300 bu.....	63	13	90	4	6
Cabbage 10 tons....	48	12	96	40	8
Apples 600 bu......	47	5	57	3	4
Leaves.............	59	7	47	.....	......
Wood growth.......	6	2	5	.....	......
Apple crop.........	112	14	109	3	4

While these crops are larger than are commonly grown they are not larger than a farmer would wish to raise, nor are they larger than it is possible and profitable to produce under good systems of soil management. And so it is for such crops we must provide in the future if we are to solve satisfactorily the problem of soil fertility.

NOTE.—The term phosphoric acid as used in fertilizer parlance refers to an oxide of phosphorus (P_2O_5) and not phosphoric acid (H_3PO_4). But it is more rational and explicit and will avoid confusion of terms if when dealing with the subject of phosphorus we speak in terms of the element phosphorus (P) instead of its numerous compounds. This is in accord with the practice of speaking of the element nitrogen (N) instead of ammonia (NH_3) as was formerly the case. One pound of P_2O_5 contains .4366 pound of phosphorus, P, and so to convert weights or percentages of P_2O_5 into P multiply by .4366, or for practical purposes .44 is sufficient. Thus 15 per ct. P_2O_5 is equivalent to 6.6 per ct. P ($15 \times .44 = 6.6$).

Similarly instead of potash (K_2O) we should say potassium (K). One pound K_2O contains .83 pound of potassium (K). To convert weights or percentages of K_2O in K multiply by .83.

SOIL COMPOSITION.

The most extensive soil types in New York State contain in the plowed soil of an acre (to a depth of 7 ins.) approximately

4,000 pounds of nitrogen
1,200 pounds of phosphorus
30,000 pounds of potassium
8,000 pounds of calcium
10,000 pounds of magnesium
No pounds of lime carbonate.

By means of these figures and those in the preceding table we can obtain some idea of the relation between the amount of plant food in the soil and the needs of crops. If the entire stock of plant food could be drawn upon as fast as needed by crops of the size mentioned above there would seem to be enough to last for a comparatively long time. However, viewed even in this way, the supply of some of these constituents is by no means inexhaustible. If the stock of phosphorus had been drawn upon at this rate during the entire lifetime of men now living, an amount equal to that contained in the surface seven inches of soil would have been removed.

Available plant food.— But the entire stock of plant food in the soil exists in a comparatively insoluble (unavailable) state. If this were not so it would not have remained after many centuries of weathering to which the soil has been exposed. Only a trifling amount of plant food becomes soluble (available) each year. Factors which make plant food available are: favorable physical condition of the soil as modified by texture, cultivation, drainage, etc.; moisture supply; decaying organic matter; amount of lime carbonate; action of plant roots; and many chemical and biological influences, all of which are modified by the above conditions. In any soil the amount that does become available during a given season depends upon the intensity of the factors which make it available and upon the total amount in the soil, somewhat as a banker's income is the product of his rate of interest and the amount of capital he has invested. With radical variation in the soil type, especially as to method of formation, differences may occur as to the form in which a part of the total plant food exists; and this may properly be regarded as another factor in determining the amount of available plant food.

In considering the amount of plant food in a soil the question is not so much how many years it would last if it could all be drawn upon as fast as needed, but, rather, is the total stock large enough so that with other conditions as favorable as it is practicable to make them there will be enough plant food liberated for good-sized crops.

Calcium and magnesium for the purpose of plant food are abundantly supplied if these elements are present in the form of carbonates (limestone) in sufficient quantities for neutralizing acidity and for good physical condition of the soil. For many crops enough calcium and magnesium as plant food may be furnished with little or no carbonate present; but some, especially legumes, seem to require the easily available carbonate to furnish all these elements they need. At any rate the question of supplying calcium and magnesium as plant food is entirely taken care of if limestone is applied as needed for neutralizing acidity, etc.

The problem is now narrowed down to the familiar one of nitrogen, phosphorus and potassium. With soils such as we are considering and under ordinary conditions of management the addition of small quantities of either nitrogen, phosphorus or potassium in easily soluble compounds usually produces an increase in general farm crops. But whether or not by the most practical efforts enough of these elements already in the soil can each year be made available or whether their addition as fertilizers is profitable are questions which can be decided only by carefully conducted field experiments. However, a few general considerations first deserve attention.

General considerations.— Potassium is contained in the soil in 25 to 30 times the amount of phosphorus, and as much as 10 times the amount of nitrogen. If potassium could be made available as fast as needed the supply would last indefinitely. Considering also that a good part of the potassium of most crops is again returned to the soil in crop residues or farm manure, it would seem entirely practicable by good management to do away with the purchasing of potassium for a fertilizer. The potassium problem then is apparently one of liberation rather than supply.

In proportion to the amounts used by crops, nitrogen is contained in the soil in smaller quantities than phosphorus; also there is much loss of nitrogen by leaching. The total supply in the soil would not last more than 20 or 25 years if it could be drawn upon as fast as needed. Of course it is impossible to draw upon it in this way and so it is evident that even at the outset some special provision must be made for supplementing the amount of nitrogen in the soil. The addition of decaying organic matter in the form of crop residues, green-manure crops and all available farm manure not only supplies nitrogen but is also necessary as means of liberating mineral plant food and maintaining good physical condition of the soil. We can determine by field experiments only, to what extent it pays to substitute for these materials or supplement them by the use of high-priced commercial nitrogen.

Phosphorus is contained in the soil in relatively small quantities, and clearly its supply must be renewed at an early date if large crop yields are to be maintained. To what extent it is now profitable to supplement this supply must be determined by experiments.

FIELD EXPERIMENTS.

The results of carefully conducted field experiments are the most reliable guide we have for fertilizing practice. It is idle to base recommendations in this regard upon theory, hearsay, or personal experience and leave the results of such experiments out of consideration. It is important to obtain as complete data as possible regarding the action of fertilizers on the soils within our own state. At the present time we are in need of much more data on this subject; and it is always well to supplement what we have by results from reliable work outside the state. Many important principles brought out in experiments on soils outside the state have extensive application.

Ohio experiments.— The following tabulated results taken from publications of the Ohio Agricultural Experiment Station are of the greatest significance.

Table II.— Effect of Fertilizer Elements and Combinations in Ohio Experiments.

Fertilizing materials and their cost, and total and net value of increase produced for 17 years (1894–1911), all calculated for one rotation of 5 years (Corn, oats, wheat, clover, timothy). Fertilizers divided between corn, oats and wheat.

Fertilizing materials in pounds per acre for each rotation.	Cost of fertilizer per acre for each rotation.	Average value of total increase for each 5-year rotation.		Net gain or loss (—) from fertilizers for each rotation.	
		Wooster, O.	Strongsville, O.	Wooster, O.	Strongsville, O.
Acid phosphate......320	$2 60	$16 52	$17 28	$13 92	$14 68
Muriate of potash....260	6 50	6 22	06	—0 28	—6 44
Nitrate of soda....440 Dried blood........50	14 40	8 62	1 48	—5 78	—12 92
Acid phosphate....320 Nitrate of soda....440 Dried blood........50	17 00	31 21	21 46	14 21	4 46
Acid phosphate....320 Muriate of potash..260	9 10	24 19	18 69	15 09	9 59
Muriate of potash..260 Nitrate of soda....440 Dried blood........50	20 90	10 95	4 47	—9 95	—16 33
Acid phosphate....360 Muriate of potash..260 Nitrate of soda....440 Dried blood........50	23 50	39 13	23 32	15 63	—0 18

The figures for the value of increase in the table are obtained by computing corn at 40 cents per bushel, wheat at 80 cents, stover at $3 per ton, straw at $2 and hay at $8. These figures are, of course, much below the market price of these crops, but they are as high as can safely be used in computing net gain from the use of fertilizers; for it is necessary to make ample allowance for the cost of harvesting and handling the increased crop and for applying the fertilizers.

The results of these extensive experiments on two widely different soil types in Ohio show that phosphorus when used by itself has been productive of very great increase. But nitrogen and potassium, although they have produced decided increases at Wooster and some increase at Strongsville, have in no case either singly or in any combination produced enough increase to make their use profitable. A combination of phosphorus and nitrogen, or phosphorus and potassium, or the three together, have at Wooster produced a greater net increase than phosphorus alone; but at Strongsville the opposite is true. The greatest net increase at Wooster has been from the three elements combined. The cost per acre was $23.50 and the net gain $15.63. But when $2.60 invested in phosphorus alone produces a net increase of $13.92 it is hardly profitable to increase the cost to $23.50 for the sake of a net gain of $15.63. A safer investment than this has been $9.10 for phosphorus and potassium in combination. Here the net profit has been $15.09, but the same amount of money invested in phosphorus alone would have been far more profitable. Of course if nitrogen and potassium had been used in somewhat smaller amounts the net profit from their use would have been greater. But phosphorus could no doubt be used in much larger amounts and still give a greater net increase than much smaller amounts of nitrogen and potassium.

While these experiments show that commercial nitrogen and potassium have not been profitable, yet they also show that these soils under the conditions which they have been managed do not furnish enough nitrogen and potassium for good sized crops. They emphasize the importance of supplying nitrogen by the use of farm manures and legumes, and in this way also supply some available potassium and help to make a large amount available from the supply already in the soil.

Pennsylvania experiment.— Extensive fertilizer experiments have been conducted by the Pennsylvania Experiment Station since 1882. They have been carried out on different fields with four different crops each year; corn, oats, wheat and hay (clover and timothy) being grown in each rotation. Results covering 25 years' work are published in Bulletin 90 of the Pennsylvania Station. The following table is derived from data in that bulletin.

Table III.— Effect of Fertilizer Elements and Combinations in Pennsylvania Experiments.

Fertilizing Materials Used.	Nitrogen, Phosphorus and Potassium per Acre Each 4 Years.			Cost of fertilizer.	Value of increase per acre for each rotation of 4 years.	Net gain per acre for the four crops.
	N.	P.	K.			
	Lbs.	*Lbs.*	*Lbs.*			
Dried blood	48	......	......	$8 64	—$1 61	—$10 25
Dissolved bone-black	......	42	......	4 80	11 34	6 54
Muriate of potassium	......	......	166	10 00	—0 29	—10 29
Dried blood Dissolved bone-black	48	42	......	13 44	19 95	6 51
Dried blood Muriate of potassium	48	......	166	18 64	3 86	—14 78
Dissolved bone-black Muriate of potassium	......	42	166	14 80	24 06	9 26
Dried blood Dissolved bone-black Muriate of potassium	48	42	166	23 44	30 66	7 22

Here in another state on a widely different soil type we have in general the same story as is revealed in the Ohio experiments. Phosphorus is the first limiting element of plant food. Nitrogen or potassium without phosphorus does not materially increase the yields and is used at an entire loss. In combination with phosphorus they decidedly increase the yields, though at heavy expense. The most profitable combination has at a cost of $14.80 given a net profit of $9.26. But $4.80 invested in phosphorus alone has given a net profit of $6.54.

These experiments have been conducted on a clay loam soil and no effort, other than the use of the clover and timothy sod, has been made to supply the organic matter so much needed for good physical condition and to aid in making plant food available. If organic matter had been supplied in fair amounts more nitrogen would have been furnished in this way and more potassium made available, thus rendering it still less profitable to purchase them. And in the light of other experiments we know that under such conditions phosphorus would give greater returns.

These Ohio and Pennsylvania experiments are the most extensive long-time fertilizer tests that have been conducted in this country. Attention is again called to the fact that they have been conducted on three widely different soil types. In Pennsylvania the experiments have been on a residual clay-loam soil of limestone origin. At Wooster, Ohio, it is a silt-loam hill-land soil of glacial origin,

but derived principally from sandy clays and shales, and resembling very closely the hill-land soils of southern New York. At Strongsville, Ohio, the experiments are located on a level clay loam soil very similar in formation and general characteristics to the lake front lands of New York State. At both places in Ohio the entire experiments are carried out each year on each of five different fields, and in Pennsylvania on four different fields.

Results in accord with these Ohio and Pennsylvania experiments as to the comparative value of nitrogen, phosphorus and potassium on general farm crops have been obtained at a number of other state experiment stations in eastern United States. No important experiments conducted on extensive soil types in our eastern states and with general farm crops have brought out any radically different results.

The term "general farm crops" as used above will include many others not included in the Ohio and Pennsylvania experiments. It will include probably all grain and forage crops, and even alfalfa and potatoes.

Fertilizing potatoes.—A study of all available data will show that potatoes, which are commonly supposed to require a fertilizer high in potassium, will, on the contrary, give greater returns from a phosphorus fertilizer than from either nitrogen or potassium. In fact, potassium is more often used on potatoes at a dead loss. As evidence on this point we have the results of fertilizer tests with potato-growing on Long Island, conducted by this Station on four different farms for three years each. A comparison was made between four different fertilizer mixtures all containing the same amount of nitrogen and phosphorus, but varying in potassium from nothing to 8.3 per ct. (10 per ct. K_2O). All four were used at the rate of 1000 pounds per acre. They varied in composition as follows:

	N.	P.	K.		N.	P_2O_5	K_2O.
No. 1....	4	3.5	0	or	4	8	0
No. 2....	4	3.5	2.9		4	8	3.5
No. 3....	4	3.5	5.8		4	8	7
No. 4....	4	3.5	8.3		4	8	10

The results of this test are given in the following table:

TABLE IV.—COMPARISON OF VARYING AMOUNTS OF POTASSIUM IN FERTILIZING POTATOES ON LONG ISLAND (1898–1899–1900).

NUMBER OF PLATS AVERAGED.	Fertilizer mixture applied at the rate of 1,000 lbs. per acre.	Average yield per acre for 3 years (1898–1900) on four different farms.
8	No fertilizer	89 bushels
8	4–8–0	123 bushels
8	4–8–3.5	127 bushels
8	4–8–7	129 bushels
8	4–8–10	128 bushels

The potassium in 1000 pounds of 4–8–3.5 cost about $1.65 and has only about returned its cost in the increased yield produced, while the larger amounts of potassium in the two other mixtures have been used at an entire loss. These results are the more significant in that they have been obtained on the sandy soils of Long Island, soils which are commonly supposed to be in special need of potassium.

Fertilizing meadow lands.— In view of some recent experiments it seems probable that better returns would have been realized from the nitrogen and potassium used in the Ohio and Pennsylvania experiments if a part had been applied as a top dressing for the hay crop. Timothy meadows, at least on poor land, are very responsive to applications of easily soluble plant food, especially nitrogen and potassium. The lesser benefit of phosphorus fertilizers under these conditions may be partly due to relatively smaller demands of timothy for phosphorus and partly to the fact that, applied as a top dressing, it does not leach down into the soil fast enough to be most profitably utilized by the crop.

The following table shows certain results from an experiment as to the top dressing of meadow land carried on by the Cornell Experiment Station. There were in all 14 different fertilizer treatments. The treatment of plat 713 gave the highest percentage of profit on the cost of fertilizer, while that of 725 gave the greatest net profit of any treatment. Plat 731 receiving 10 tons barnyard manure per acre once in 3 years is not considered in the comparison of profits.

Table V.— Average of Three Years Results in Fertilizing Timothy Meadows (1905–07).

Plat No.	Pounds of fertilizers used per acre annually.	Cost of fertilizers per acre annually.	Increase of hay per acre annually.	Value of annual increase at $10 per ton.	Net gain per acre.
			Lbs.		
712	320 acid phosphate	$2 24	682	$3 41	$1 17
713	80 muriate of potassium	1 84	988	4 94	3 10
715	160 nitrate of soda	4 48	1,211	6 05	1 57
716	320 acid phosphate 160 nitrate of soda	6 72	1,614	8 07	1 35
718	320 acid phosphate 80 muriate of potassium	4 08	1,079	5 39	1 31
719	160 nitrate of soda 80 muriate of potassium	6 32	2,111	10 55	4 23
725	320 nitrate of soda 320 acid phosphate 80 muriate of potassium	13 04	4,192	20 96	7 92
731	10 tons of manure once in three years	?	2,975	14 87	?

$11\frac{1}{2}$ bushels per acre. $35\frac{1}{2}$ bushels per acre.

INFLUENCE OF LIMESTONE AND NATURAL ROCK PHOSPHATE ON SOIL PRODUCTIVITY.

This grain was grown in southern Illinois, on land practically abandoned ten years before, and then purchased by present owner for \$15 per acre. During the past ten years the land has received only one application of manure, of 8 or 10 tons per acre, and limestone and natural rock phosphate averaging \$1.75 worth per acre per year. (At present New York State prices for these materials the cost would be about \$2.70 per acre.) The soil on this farm is as light-colored and as deficient in organic matter as the hill-land soils of southern New York. It is altogether probable that similar treatment with limestone and phosphorus would give as satisfactory results on New York soils.

(See Circular 168, Illinois Agricultural Experiment Station, Urbana, Ill.)

This gives some idea of what may be expected in the way of immediate returns from the fertilizing of timothy meadows. Nitrogen and potassium have been more profitably utilized here than when applied to other crops in other experiments described, and yet the profit from their use is largely absorbed in their cost. But the heavier sod resulting from the fertilizing of the hay crop has its effect upon succeeding crops as do also some fertilizer residues; so that the average of several rotations should be considered to give a fair estimate of this method of fertilizing. The results on a succeeding crop of corn as published in Cornell Bulletin 273 are suggestive of the effect on other crops in the rotation.

It seems probable that at the outset of building up run-down land nitrogen and potassium can be used profitably as a top dressing for timothy meadows, thus producing a good crop and at the same time improving the soil for following crops. For this purpose, though, barnyard manure is better and should be used instead as far as it is available. There is no evidence, however, that this method of fertilizing will in the long run alter general results as to the comparative value of nitrogen, phosphorus and potassium fertilizers brought out in the long time field experiments. The direct effect of commercial nitrogen is almost all spent the first year, and the same is largely true of potassium; while phosphorus benefits succeeding crops as long as any is left.

The question of manure.— The effect of farm manure is to supply readily available nitrogen and potassium and to increase the organic matter content of the soil. This tendency is decidedly to lessen the effects of the application of commercial nitrogen and potassium. The amount of phosphorus carried in manure is slight and the actual effect of an application of manure or decaying vegetable matter of any kind is to increase the benefits from an application of phosphorus fertilizer. Evidence on this point is found in the Ohio experiments on the reenforcement of manure. The manure is applied at the rate of 8 tons per acre once in three years, to the corn crop, in a rotation of corn, wheat and hay. The experiment was carried out on three different fields each year, and the results here mentioned cover 15 years. The average value per acre of the increase in the three crops for each rotation due to the treatment of 8 tons of manure was $23.52. When the eight tons was reenforced with 320 lbs. of acid phosphate the increase was $38.59. Thus the increase due to the acid phosphate was $15.07. On the same farm the increase due to 320 lbs. of acid phosphate per acre each five years in a 5-year rotation covering nearly the same period of time was $16.52 for the five crops instead of three. Other data given later in these pages also illustrate this fact.

Phosphorus and limestone.— In view of such evidence as has been presented, and until any radically different evidence is obtained, the conclusion seems justified that when growing general farm crops

the farmer who cannot spend more than about $2 per acre per year for fertilizers would best *spend all of this for phosphorus and limestone*; or if his land does not need lime spend the greater part of it for phosphorus. He should also in every way practicable supply liberal amounts of organic matter by the use of all available farm manure, crop residues and occasional green-manure crops, making use to a large extent of legume crops, which have the ability of securing nitrogen from the air. The statement is ventured that the majority of New York State farmers have not money to spend for fertilizers beyond $2.50 per acre per year for their entire land in crops. But at this cost phosphorus and lime carbonate can be supplied in larger quantities than they are reduced by cropping and thus the soil be positively enriched in these materials. There is good evidence to show that by this method the soil can be brought up to a high state of fertility and good crop yields indefinitely maintained. The following specific examples are illuminating:

A practical farmer has bought run-out land in southern Illinois at $15 per acre and at an annual expense of $1.75 per acre for limestone and phosphorus for the last ten years has gradually increased the yields to 35½ bushels of wheat per acre in 1913. Check strips not so treated produced 11½ bushels per acre for the same year.

Another Illinois farmer on more productive land by the expenditure for the previous five years of $1 per acre per year for phosphorus alone (his land not being in need of additional lime carbonate) has increased the yield of corn from 54 bushels per acre to 70 bushels; oats from 47 bushels to 70 bushels, and clover hay from 1½ tons to 2½ tons; these yields being 5-year averages.

At the Illinois State Experiment Station wheat has yielded 34.2 bushels per acre on land treated with cover crops and farm manure. On land similarly treated except for the addition of phosphorus at the rate of $1.90 worth per acre annually for the past four years the yield at the same time has been 51.8 bushels of wheat.

It is important to note that results brought out by field experiments as to the needs of soils for phosphorus, lime carbonate and organic matter, and the unprofitableness in most cases of supplying nitrogen and potassium in commercial forms are in accord with the logical inferences to be made from the data revealed by chemical analyses. The two together form a safe foundation upon which to base a rational system of soil management.

Carriers of phosphorus.— The principal fertilizing materials that can profitably be used for supplying phosphorus are the following:

	Per ct. P.		Per ct. P_2O_5
Acid phosphate, containing	6– 7	or	14–16
Bonemeal, containing	9–12		20–27
Basic slag phosphate, containing	7– 8		16–18
Natural rock, containing	12–14		28–32

No treatment. One ton natural rock phosphate per acre.

Rye Grown on Adjacent Plats in Fertilizer Test, Chautauqua Co., N. Y.

Without special treatment this soil would not grow enough rye to cover the ground. A rank growth of rye followed use of natural rock phosphate, so that it was more than waist high when plowed under on May 10, 1913. Similar results were obtained on another field a few miles distant, and the two fields are typical of large areas of soil in some parts of this State. However, to secure the best results rock phosphate should be plowed under with liberal amounts of organic matter; which was not the case here.

Wheat on Adjacent Plats of Fertilizer Experiment at Ohio Agricultural Experiment Station.

Corn, oats, wheat, clover and timothy have been grown in rotation for 20 years on five series each of 30 plats. Plat 1 receives no fertilizer nor manure and all crops are removed, while Plat 2 receives 320 lbs. of acid phosphate in a rotation — 80 for corn, 80 for oats and 160 for wheat. The wheat photographed above (crop of 1909), yielded 18.9 bushels per acre on Plat 1 and 29.9 bushels on Plat 2. The 10-year average (1904–1913) on Plat 1 is 13 bushels per acre and on Plat 2, 21.6 bushels.

On other plats in this experiment the use of commercial nitrogen and potassium, in addition to phosphorus, has given increased yields but only very slightly increased profits over use of phosphorus alone.

Acid phosphate is made by treating natural rock phosphate with about an equal weight of sulphuric acid, thus making the phosphate more soluble (available). Bonemeal is sometimes treated with sulphuric acid in the same way to make acid phosphate; but the product of this treatment is more commonly called dissolved bone or acidulated bone. Acid phosphate made in either of these ways contains phosphorus in the most readily available form of any of the above-named phosphorus fertilizers. Bonemeal, either raw or steamed (the latter being preferable) is now about the highest-priced form of the above phosphates; otherwise, it has been found a very desirable form of phosphorus. The high prices for bonemeal are due to charging full prices for the nitrogen which it contains. But in buying phosphates one wishes to pay only for phosphorus.

Basic slag is a waste product from the manufacture of steel from iron ore which contains some phosphorus. In addition to phosphorus it contains a small amount of lime capable of neutralizing acidity (equal to perhaps 20 per ct. of lime carbonate). The Ohio station has compared equivalent amounts of phosphorus in acid phosphate, basic slag and bonemeal and found almost identically the same results from the three. The comparisons have been made on two widely different soil types and for a period of 18 years on each. At each place all three forms were compared on each of five different fields each year in a rotation of corn, oats, wheat, clover and timothy.

Phosphorus in the form of finely ground natural rock phosphate can be obtained directly from the southern mines at one-third to one-fourth the cost of any of the other three forms. But the phosphorus in the natural rock is not so readily available as in the other forms, and applied in the way fertilizers are commonly used, a few hundred pounds per acre at the time of seeding, satisfactory results are seldom obtained. However, when applied in connection with liberal amounts of decaying organic matter, such as farm manure, green manure or heavy sods, much more satisfactory results are secured. This is logically explained by the action of the decaying organic matter helping to make the phosphate available, just as it is one of the most important factors in making other mineral plant food in the soil available. It is no objection to the use of rock phosphate that liberal amounts of organic matter must be used with it, for such is entirely necessary to the most profitable management of soils under any condition; and, as already shown, is about the only profitable way of supplying nitrogen and potassium.

At the Ohio Experiment Station natural rock phosphate has been compared with acid phosphate as reenforcement for manure. The comparison has been made on three different fields for 15 years in a rotation of corn, wheat and hay. The manure is applied at the rate of 8 tons per acre once in three years, to the corn crop, and 40 pounds of acid phosphate or 40 pounds of natural rock phosphate

mixed with each ton of manure. The comparison is made on fresh stall-manure and weathered yard-manure separately. The average annual yields per acre for the three crops for this length of time are given below:

	Cost of phosphate.	Corn, bu.	Wheat, bu.	Hay, lbs.
Yard manure	......	53.2	19.3	3,446
Yard manure and rock phosphate	$1 40	61.8	24.0	4,540
Yard manure and acid phosphate	2 40	62.3	24.2	4,376
Stall manure	......	59.5	20.7	4,150
Stall manure and rock phosphate	1 40	65.4	25.4	5,020
Stall manure and acid phosphate	2 40	66.0	25.5	5,077

It is to be noticed that in this comparison of equal weights of acid phosphate and rock phosphate the two have given almost identically the same yields. But the acid phosphate has cost nearly double that of the rock phosphate and the question naturally arises what would have been the result of applying rock phosphate to the same money's worth as acid phosphate. Then, too, even in the amounts used the natural product is supplying the soil twice as much phosphorus as the acid material, and must mean something for the future.

A good way to apply rock phosphate is at the rate of 1000 to 2000 pounds per acre once in a three- to six-year rotation, plowing it under with a clover or alfalfa sod, or with an application of manure, or with both sod and manure. In the three examples cited above from Illinois the phosphorus used has been natural rock phosphate and it has been plowed under with the clover sod once in a rotation. At New York State prices for rock phosphate an application of 1000 pounds per acre once in 3 years would be an expense of about $1.50 per acre per year.

The practice of using the natural phosphate in liberal quantities appeals to the farmer who has an understanding of the principles of soil fertility and who views his business in a large way, looking not only to the profits of the present season but also to the net returns over a period of years.

HOME MIXING OF FERTILIZERS.

Some truck and some fruit crops, tobacco, and a few others require relatively larger amounts of nitrogen and potassium than general farm crops. Also these crops usually have a much higher value per acre. It may, therefore, often be profitable to use liberal amounts

of nitrogen and potassium fertilizers in such cases. A comparatively small increase in crop due to their use would more than pay for the fertilizer. However, if fair amounts of phosphorus and lime carbonate are used in these cases, and if liberal supplies of nitrogenous organic matter are kept up, the needs for commercial nitrogen and potassium are very much reduced. Also sixteen years of experiments in the fertilizing of an apple orchard at this Station indicates that much of the land devoted to commercial apple growing in the State does not need any commercial fertilizers for the apple crop.

In building up a run-down farm it may often be advisable, as has been suggested above, to make use for a while of a certain amount of commercial nitrogen and potassium, restricting their use largely to grass and small grain. For potatoes some nitrogen will be used.

Because of the legitimate use in many cases for a fertilizer containing all three of the common fertilizing elements, something may be said here regarding so-called complete commercial fertilizers and the practice of mixing the different materials on the farm.

Buy fertilizing materials.— There are decided advantages in buying the separate fertilizing materials and mixing them according to one's need rather than purchasing some brand of mixed goods.

(1) A mixed fertilizer usually sells for a higher price than ingredients which go to make it up can be bought for separately. This is because of a charge for mixing and bagging and because of the assumed merits of that particular brand.

(2) A mixed fertilizer sometimes carries a part of its nitrogen or phosphorus in comparatively unavailable forms, although these are sold for as high a price as if they were of the best grade. Thus nitrogen in peat used as a "filler" may be sold for the same price as nitrogen in dried blood. The analyses made under the State Inspection Law do not entirely reveal the forms in which the elements of a fertilizer are contained.

(3) Mixed fertilizers seldom contain the three elements in the most suitable proportion for the soil and crop in question.

All this is well understood by many practical men, but the enormous sale of mixed commercial fertilizers within the state is proof that it is not appreciated by the majority of landowners. At the Ohio Agricultural Experiment Station a comparison between home-mixed and factory-mixed fertilizers was conducted on each of three different fields for a period of eight years. The results are so significant that they are republished here.

For the purpose of this test four brands of mixed fertilizers were purchased on the open market from four prominent fertilizer establishments. These brands were then duplicated by a mixture of tankage, acid phosphate, muriate of potassium and a filler. The commercial brands and their duplicates were then compared side by side on three different fields for eight years, corn, wheat and clover being grown in rotation on these fields. The fertilizers were all

applied at the rate of 200 pounds per acre on corn and wheat, making an application of 400 pounds for each three-year rotation.

The following table of results has been taken from Ohio Station Bulletin 260. It has been modified in that the increases of stover and straw are omitted for the sake of brevity. One dollar per ton has been added to the cost of the duplicate fertilizer to pay for mixing, and the price of bonemeal has been increased to $25 per ton.

TABLE VI.— COMPARATIVE EFFECT OF HOME-MIXED AND FACTORY-MIXED FERTILIZERS: OHIO EXPERIMENTS.

Average yearly increase per acre in comparison of factory-mixed with home-mixed fertilizers, cost of fertilizers and net gain for one rotation.

FERTILIZER AND FORMULA.	Cost of fertilizer per ton.	AVERAGE INCREASE PER ACRE.			Value of increase.	Cost of fertilizer (400 pounds).	Net gain.
		Corn, bushels.	Wheat, bushels.	Hay, pounds.			
Brand A, 4–8–4*....	$30 00	7.8	9.7	675	$14 72	$6 00	$8 72
Duplicate A, 4–8–4..	19 24	6.1	11.7	910	16 52	3 85	12 67
Brand B, 2–10–1....	25 00	5.6	11.2	658	14 74	5 00	9 74
Duplicate B, 2–10–1.	17 47	10.9	14.5	1,021	21 50	3 50	18 00
Brand C, 2–8–1....	20 00	5.0	7.0	458	10 11	4 00	6 11
Duplicate C, 2–8–1..	14 41	4.5	8.4	447	11 23	2 88	8 35
Brand D, 1–6–1....	17 50	5.7	8.5	350	11 45	3 50	7 95
Duplicate D, 1–6–1.	10 10	4.6	8.8	355	11 28	2 02	9 26
Raw bonemeal.....	25 00	7.6	13.2	1,309	20 24	5 00	15 24
Steamed bonemeal..	25 00	11.2	14.9	1,300	23 38	5 00	18 38

* 4–8–4 = nitrogen (N) 4 per ct., phosphoric acid (P_2O_5) 8 per ct., potash (K_2O) 4 per ct.

The results of this experiment plainly show that home-mixed fertilizers may be $5 to $10 per ton cheaper than ready-mixed fertilizers showing the same percentages of nitrogen, phosphorus and potassium. Furthermore the home-mixed goods have produced better yields, doubtless due to their being made of better materials. When we consider the difference in net gain as a result of these two facts it is so greatly in favor of home mixing that we are justified in advising the farmer to *avoid, as a rule, the buying of mixed commercial fertilizers.* There are probably instances of cooperative buying where a special mixture made up of good materials is obtained

at practically the cost of materials separately. In such cases there may be some advantages in buying the mixed goods since it saves the slight inconvenience of home mixing. But the difficulty here is that the formula is seldom determined by those who know in what proportions the three ingredients can be most profitably used. For example take the Long Island formula 4–8–10 which is put up especially for the potato growers of Long Island. This formula is very generally used although experimental evidence shows that it contains at least three times as much potassium as is profitable. The large increase produced by bonemeal in this experiment again testifies to the value of phosphorus.

How to mix fertilizers.— If one has decided upon a certain number of pounds per acre of each of two or more fertilizing materials, as for instance 100 lbs. nitrate of soda, 300 lbs. acid phosphate and 50 lbs. muriate of potassium, then obviously he has only the very simple problem of mixing these three materials in those proportions and applying 450 lbs. per acre of the mixture. Indeed, it is hardly necessary to make the problem of home mixing any more complicated than this.

However, as the farmer begins to study more intently the subject of fertilizers he will soon begin to think of pounds nitrogen, phosphorus and potassium per acre instead of pounds of the fertilizing materials per acre. This method is, of course, more definite since the different materials carrying nitrogen, phosphorus and potassium vary greatly in the percentage of the fertilizing element which they carry; but the problem is almost as simple as in the first case. The mixer has only to compute the number of pounds of the purchased materials needed to supply the quantities of the elements used per acre, by dividing the number of pounds of each element required by the percentage of it found in the material used. Suppose, then, he decides to apply per acre 15 lbs. of nitrogen, 20 lbs. of phosphorus and 20 lbs. potassium, and that he selects as materials to be used nitrate of soda (15 per ct. N), acid phosphate ($6\frac{2}{3}$ per ct. P = 15 per ct. P_2O_5) and sulphate of potassium (40 per ct. K = 48 per ct. K_2O). The computation will be as follows:

Element.	Lbs. needed per acre.		Percentage in material.		Lbs. of material to be used.
N.	15	÷	.15	=	100 nitrate of soda.
P.	20	÷	$.06\frac{2}{3}$	=	300 acid phosphate.
K.	20	÷	.40	=	50 muriate of potassium.
					450 mixture.

These materials are then mixed in those proportions, and 450 lbs. (the sum) applied per acre. The arithmetic is sometimes more complex than this, but in any case it is only a simple problem in percentage.

If the percentages of the different elements in such a mixture are desired, it is only necessary to divide the number of pounds of each element by the whole number of pounds in the mixture. In the ex-

ample worked out, for instance, the N would be $15 \div 450 = 3\frac{1}{3}$ per ct., the P 4.4 per ct., and the K 4.4 per ct. Having these percentages given it is very easy to calculate the amount of the mixture required to give a certain amount of any one element per acre.

Sometimes the farmer desires to use N, P and K in a certain proportion as 1–2–1, 2–4–3, 3–5–2, etc. In this case the simplest method of procedure is to decide, also, how much of one of the elements will be used per acre, and with this as a basis to reduce the proportion chosen to a formula of pounds per acre and compute as above. If the proportion 2–4–3 be selected and 20 lbs. of nitrogen to an acre be taken as a basis, the formula will become 20–40–30, by dividing 20 by 2 and multiplying each term of the proportion by the quotent, 10. If 3–5–2 be selected as the proportion and 60 lbs. of P per acre as the basis the formula will become 36–60–24. If a different basis per acre is decided upon after such a mixture has been made, the amount to be used can be found from the percentages, computed as above.

It will often happen that only two elements are desired in a mixture. This would simplify still further the above calculations.

In the above calculations, nitrate of soda, acid phosphate and sulphate of potassium have been used only for example and not because of preference for those particular forms of the three elements.

It is never advisable to decide first upon definite percentages of N, P and K, as for instance 2 per ct. N, 4 per ct. P, and 3 per ct. K, and then attempt to make the mixture conform to this arbitrary formula. Such will usually require the addition of some make weight or "filler," or it may be the materials are too low in composition for the formula. There is no good sense in going to the expense of mixing sand or dry earth with a fertilizer simply to increase its weight and make it conform to a certain formula. Fertilizer companies do this and let the farmer pay all the extra expense involved. The only good reason for ever using a filler is to act as a drier or absorbent in connection with certain moist salts: as calcium nitrate, potassium chloride, or even sodium nitrate. A certain amount of dry absorbent material may be added in such cases to insure good mechanical condition and prevent the formation of lumps. For this purpose nothing is better than fine dry peat or muck. But unless the fertilizer is to stand several weeks or months after mixing there is no need of this precaution.

If we leave out of consideration all forms of caustic lime (and there is never any need of using such in a mixed fertilizer) there are very few other materials used in fertilizers but can be mixed together freely without unfavorable results. Basic slag is the one to be especially mentioned. It contains a small amount of caustic lime and should not be mixed with ammonium compounds, nor acid phosphate. In any mixture it should not stand long after mixing because of its tendency to cause caking. Wood ashes have some-

what the same tendencies as basic slag, owing to their containing basic compounds. Ground limestone or marl should not be mixed with soluble phosphate; but at any rate they have no place in a fertilizer mixture. They can better be applied alone since they must be used in relatively large quantities.

A smooth floor, a shovel and a suitable pair of scales are about all the machinery necessary for home mixing of fertilizers. If a grinding machine is available it is sometimes possible to make use of cheaper fertilizing materials, such as coarse bone and tankage or lumpy materials. But it is always practicable to obtain materials in good mechanical condition for immediate mixing.

A list of the most common fertilizing materials used for home mixing, together with the approximate percentages of nitrogen, phosphorus and potassium which they contain are given below. These materials, especially the organic products, vary in composition and are always purchased on guaranteed analysis.

	N.	P.	$= P_2O_5$.	K.	$= K_2O$.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Acid phosphate	......	6.5	15	......	....
Bonemeal (raw)	3	10	23	......	....
Bonemeal (steamed)	2	11	25	......	....
Dissolved bone	......	6	14	......	....
Dissolved bone-black	......	6	14	......	....
Basic slag	......	7.5	17	......	....
Tankage	4	5.5	12	......	....
Tankage	10	2	4.5	......	....
Dried blood	12	1	2.5	......	....
Cottonseed meal	8	......	......	......	....
Nitrate of soda	15	......	......	......	....
Ammonium sulphate	20	......	......	......	....
Muriate of potassium	......	......	......	42	50
Sulphate of potassium	......	......	......	40	48
Kainit	......	......	......	10	12

Some or all of these materials may be obtained from any of the large fertilizer concerns either directly or through their agents. The names of all fertilizer companies operating in this State are to be found in the annual fertilizer inspection bulletin put out by this Station.

Natural rock phosphate, finely ground, containing 11–14 per ct. phosphorus (27–32 per ct. P_2O_5) can be obtained in car lots direct from southern mines through the companies named on the next page. Prices on car lots delivered to New York points range from $7.50 to $10 per ton.

Farmers' Ground Rock Phosphate Co., Mt. Pleasant, Tenn.
Robin Jones Phosphate Co., Nashville, Tenn.
Mt. Pleasant Fertilizer Co., Mt. Pleasant, Tenn.
Ruhm Phosphate Co., Mt. Pleasant, Tenn.
Powdered Rock Phosphate Co., Columbia, Tenn.
Blue Grass Phosphate Co., Mt. Pleasant, Tenn.
Federal Chemical Co., Columbia, Tenn.
Central Phosphate Co., Mt. Pleasant, Tenn.
Central Kentucky Phosphate Co., Wallace, Ky.

A list of companies in New York State producing ground limestone or marl for agricultural use is given below.

Ground limestone of good grade (the total passing a sieve with ten meshes to the linear inch, and containing at least 90 per ct. carbonates) can be obtained in bulk, carload lots, f.o.b. quarries, at $1 to $2 per ton. The added freight charges make this $1.50 to $3 per ton delivered to the farmer's railway station. For most soils in this state ground limestone should be used in liberal quantities, and its cost ought not to exceed $3 per ton including freight. In the greater part of the state it can be obtained for much less.

Adams & Duford Co., Chaumont, N. Y.
Buffalo Cement Co., Buffalo, N. Y.
B. & B. Lime and Stone Co., Mellenville, N. Y.
Caledonia Chemical Co., Caledonia, N. Y.
Callanan Road Improvement Co., S. Bethlehem, N. Y.
Chazy Marble Lime Co.; Chazy, N. Y.
Conley Stone Co., Utica, N. Y.
Cobleskill Limestone Co., Cobleskill, N. Y.
Empire Limestone Co., Buffalo, N. Y.
Harrison, John J. E., Newburgh, N. Y.
Langdon & Co., Elmira, N. Y. (quarries in Schoharie and Niagara counties).
Morse, Frank E., Co., 17 State St., New York City.; quarries in Dutchess Co.
Northern Crushed Stone Co., Ogdensburg, N. Y.
Rock Cut Stone Co., Syracuse, N. Y.
Roberts, George H., 17 State St., New York City.
Sugar River Stone Co., Boonville, N. Y.
Upper Hudson Stone Co., 26 Cortlandt St., New York City; quarry, Verplanck Point.
Valley Stone Co., Schenectady, N. Y.
Wait, F. W., Co., Glens Falls, N. Y.
Whittlestone Limestone Co., Medina, N. Y.
Worlock Stone Co., Canastota, N. Y.

All the above references are given only as a matter of information. The Station makes no recommendations or guarantee as to reliability.

GROUND LIMESTONE FOR SOIL IMPROVEMENT.*

J. F. BARKER.

"A limestone country is a rich country" is a saying long ago common among British and European farmers; but the truth of the maxim is just as well illustrated in the experiences of American agriculture. There are within the United States certain large continuous areas of limestone land, regions in which the soil is derived from the disintegration and decomposition of limestone rock. Some of these sections, because of the productivity and durability of their soils and the consequent prosperity of the farming population have become famous agricultural districts. The Blue Grass region of western Kentucky and Tennessee, on the whole one of the most excellent farming sections in eastern United States, illustrates this fact. Another notable example is the beautiful Shenandoah Valley of Virginia and southeastern Pennsylvania, which is not an ordinary river valley but a fold in the earth formed by a mountain chain on either side. Massive beds of limestone have been formed in this depression, and it is from these limestones that the famous soils of the Shenandoah valley are derived. In Ohio that region through which the Miami river flows is the most prosperous agricultural section of the state, and here the character of the soil is largely influenced by extensive beds of phosphatic limestone.

But we have nearer at home just as forceful illustrations of the proverb "A limestone country is a rich country," for in those sections of New York State in which extensive limestone formations outcrop the soils are notably the best. A section of country from Utica to Buffalo along the main lines of the New York Central and West Shore railroads and varying in width from 10 to 30 miles is the cream of the state. Throughout this region the glacial till contains limestone gravel and boulders from the Onondaga and Niagara formations. Here the soils are naturally adapted to alfalfa and here is included the greater part of the fruit-growing districts of the state.

The excellence of limestone soils of course does not depend entirely upon the carbonates (limestone) which they now contain. They are usually well supplied with the mineral elements of fertility, and the phosphorus in these soils may be somewhat more readily available than in many others for the reason of its being present largely in the form of calcium phosphate, whereas in other cases it may occur mainly as iron or aluminum phosphate.

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* Reprint of Circular No. 27, January 20.

SOLUBILITY OF LIMESTONE.

Under natural conditions limestone (calcium carbonate or calcium and magnesium carbonates) is more soluble than most other soil constituents and is easily leached away. The easy solubility of this material is illustrated by the fact that the lime carbonate in many feet of limestone has often been leached away to form one foot of soil, which is made up mainly of the impurities contained in the lime rock. Also the caves and sink-holes found in limestone regions are due to the dissolving away of the rock by underground waters. In an even more forceful way the solubility of limestone is illustrated by the large quantities of it contained in spring and well waters, it being the material which makes such waters hard and which is deposited as a crust in kettles and boilers when the water is evaporated. As a consequence of the comparatively easy solubility of lime carbonate the great majority of soils in eastern United States not naturally well stocked with lime, and, especially those long cultivated, are now deficient in that material. The processes of cultivating and cropping tend to cause a more rapid leaching of lime from the soil as well as removing it in crops. Even limestone lands when long cultivated often respond favorably to an application of ground limestone.

FUNCTION OF CARBONATES IN SOILS.

The chief function of carbonates in the soil is the neutralizing of acidity. In natural soil processes acids are produced from the decaying of organic matter just as acid is formed in the souring of milk, in the production of sauerkraut, in the fermenting of silage and in the manufacture of wine and vinegar from fruit juices. Also by the process of nitrification nitrogen in the organic matter of the soil is converted into the strong mineral acid — nitric acid. It is important to have in the soil at all times a material like limestone which will keep these acids neutralized, but otherwise produce a neutral or only faintly alkaline reaction. Lime carbonate also gives to soils a better tilth by tending to produce a flocculated or crumb structure; while acids have the effect of causing the soil to run together in a more or less compact mass, which is just the opposite of tilth. Some soils actually contain an insufficient amount of calcium and magnesium for use as plant food, and in such cases limestone has the important function of furnishing these elements in easily available form. Many farm crops use an insignificant amount of calcium and magnesium as plant food; but a few, notably clover and alfalfa, use them in relatively large amounts. One ton of cured alfalfa hay contains these elements in a total amount equivalent to as much as 100 pounds of limestone.

Nearly all farm crops are sensitive to an acid condition of the soil, but clover, alfalfa, vetch, bluegrass, timothy, beets and others can

scarcely be grown with success unless a fair amount of lime carbonate is present. On acid soils timothy hay and many other of the grasses will respond generously to liming. Corn, oats, barley and wheat themselves often will give returns from the direct application of lime sufficient to pay for its use. Potatoes and nearly all garden and truck crops demand a normal amount of lime carbonate for their most profitable production. With fruit the tendency of lime seems to be to check excessive wood growth and promote fruitfulness. A few eccentric plants, including the blueberry, cranberry, serradella, and common sorrel are said to reach their best development on acid soils. A slightly acid reaction of the soil probably does not directly affect plant roots, but a neutral condition or one bordering on an alkaline reaction is important to the welfare of beneficial microorganisms and those processes which make for the production of available plant food.

CHEMISTRY OF LIMES.

Not only natural raw ground limestone but also freshly-burned and hydrated lime may be used for the purpose of supplying lime to soils deficient in lime carbonate. Freshly-burned and hydrated limes, however, rapidly change over to the carbonate form on being applied to the soil; that is, they shortly become of the same composition as raw ground limestone, a process familiar to everyone in the changes that lime mortar undergoes on standing. If it were not for this fact neither of the caustic forms of lime could be used on the soil, for as long as they exist in the caustic condition they are liable to be injurious.

For many farmers one of the most perplexing questions that has arisen in connection with the whole problem of supplying the soil with lime carbonate is what form of lime is best to use or what is the relative value and efficiency of the different forms. When pure calcium limestone ($CaCO_3$) is completely burned it loses 44 per ct. of its weight, yet the resulting product, which is calcium oxide (CaO) or quicklime, contains just as much actual lime as the original limestone. It follows then that 56 pounds of pure quicklime is equal to 100 pounds of pure limestone. The above weight of quicklime slaked with just the right amount of water forms 74 pounds of hydrated lime, ($Ca(OH)_2$). When either of these compounds is exposed to air for a long time it completely recovers the weight lost in burning; thus " air slaked " lime is nearly the same as pulverized limestone. Now limestone is never entirely pure; good grades may contain as much as 5 per ct. of impurities, consisting chiefly of clay-like material. On burning, these impurities do not lose in weight like the rest of the stone, consequently burned lime will contain a higher percentage of impurities than the stone from which it is burned. Also, burned lime begins to take up weight again as soon

as it is exposed to the air. The figures above, then, are changed somewhat in actual practice. For practical purposes it may be remembered that 1200 pounds of freshly-burned lime, 1500 pounds of hydrated lime and 2000 pounds of ground limestone all contain approximately the same amount of actual lime, and are capable of neutralizing the same amount of acidity when applied to the soil, provided all forms are of good grade. Bulk lump lime offered to the agricultural trade at $4 to $5 per ton is not as good a grade as that considered in these figures. In fact, it often contains the ashes from the coal used in burning, may contain some unburned core, and may be partly air-slaked. Ground limestone (or its equivalent, "air-slaked lime,"), quicklime and hydrated lime are the only three forms that can properly be called lime or that can be used for neutralizing acidity in the soil. Marl is the same in composition as ground limestone and when it contains the same percentage of carbonates is of equal value. "Agricultural lime," "Land lime," etc., are only trade names given to any one of the three forms or a mixture of them.

Magnesium limestones are such as have a part of the calcium carbonate replaced by magnesium carbonate ($MgCO_3$). Magnesium carbonate is also efficient for neutralizing soil acidity, in fact a given weight of it will neutralize somewhat more acidity than the same weight of calcium carbonate, due to a difference in the molecular weights of the two compounds. One hundred pounds of magnesium carbonate is chemically equivalent to 119 pounds of calcium carbonate. Limestone carrying calcium and magnesium carbonates in proportion to their molecular weights (100:84) are known as dolomites. A limestone having 75 per ct. calcium carbonate and 20 per ct. magnesium carbonate is equal in neutralizing power to one having 98.8 per ct. calcium carbonate. Owing to these facts and also to the fact that magnesium as well as calcium is an essential element of plant food, magnesium limestones sometimes give somewhat better results than straight calcium stones. However, magnesium salts in excessive quantities often have a toxic effect on plants, and so on some soils already containing large amounts of magnesium the application of magnesium limestones may not give as good results as straight calcium stones.

COMPARATIVE EXPERIMENTS WITH GROUND LIMESTONE AND BURNED LIME.

Because of the caustic properties and finely powdered condition of burned lime, the theory has often been advanced that it is better to use than the carbonate. There is no evidence, however, from any carefully conducted field test to show that this is ever the case. On the other hand seven years of comparative trials in the field at the Ohio station, eleven years at the Maryland station and twenty-

five years in Pennsylvania, together with much other evidence from this and from foreign countries, have shown that ground limestone gives at least as good results and often better than its equivalent in burned lime. These experiments cover soils of various types, containing much and little organic matter; and they deal with small, medium and large applications of lime, and with nearly all general farm crops.

Ohio experiments.— At the Ohio Station comparative experiments have been made with equivalent amounts of freshly-burned lime, ground limestone, air-slaked lime and hydrated lime in a rotation of corn, oats and clover. The work has been carried out each year on three different fields. The average results for seven years are given below:

BURNED LIME VS. GROUND LIMESTONE: OHIO EXPERIMENTS; 7 YEARS' RESULTS.

	Value of increase per acre each 3 years. Rotation corn, oats, clover.	Cost of lime.	Net gain per acre each 3 years.
Freshly-burned lime 1000 lbs.; manure 8 tons..	$11.83	$3.00	8.83
Freshly-burned lime 2000 lbs.; manure 8 tons..	14.52	6.00	8.52
Ground limestone 1780 lbs.; manure 8 tons....	13.60	2.70	10.90
Air-slaked lime 1780 lbs.; manure 8 tons......	12.03	5.30	6.73
Hydrated lime 1320 lbs.; manure 8 tons.......	13.21	4.00	9.21

The values of the increased crop yields are computed at the following figures: corn 40 cents per bushel, oats 30 cents, corn stover, $3 per ton, oat straw $2, hay $8. These prices are of course below the market price of these crops, but the lime or fertilizer gives us the increase standing in the field and so ample allowance must be made for harvesting and handling the increased crop and for applying the lime or other materials.

In these experiments the land was in good condition at the outset, yielding 60 to 70 bushels of corn per acre, so that the chief problem has been to maintain the yield. Lime and manure have not only maintained but have decidedly increased the yields. Manure is applied to the clover sod before plowing and the lime is applied to the rough surface after plowing. It is important to note that in this experiment the amounts of the different forms of lime that are used in comparison are smaller than are needed by the soil, as shown by heavier applications giving larger increases in crop. This fact makes the comparison the more accurate.

Tennessee experiments.— At the Tennessee station comparative experiments with ground limestone and caustic lime have been conducted for four years with a variety of crops, including corn, wheat, oats, barley, sorghum, clover, grass, cow peas and cotton. The results of the experiments are summarized in the following paragraph quoted from Tennessee Station Bulletin 97:

" The most important feature of these experiments consists, however, in the comparative returns from burned lime on the one hand and ground limestone on the other. A study of Table V shows that the returns are very close. If the increased yields of all hay attributable to liming be summed up, we find an average increase for each crop harvested of 0.67 ton per acre for the burned lime and 0.69 ton per acre for the ground limestone. If the increased yield of all kinds of grain crops be averaged in a similar manner we find an average increase of 4.5 bushels for the burned lime and 5.5 bushels for the ground limestone. We would conclude, therefore, that in these trials two tons of ground limestone proved somewhat superior to one ton of burned lime."

Particular mention is made in the bulletin that the burned lime was strictly high grade.

Maryland experiments.— Eleven years of comparative experiments with burned lime and carbonate of lime have been reported by the Maryland station. Each form of lime is tested on duplicate plats. On one plat the burned lime is from limestone and on the other from oyster shells. The carbonate is from marl in one case and in the other from ground oyster shells.

CAUSTIC LIME VS. CARBONATE OF LIME: MARYLAND EXPERIMENTS; 11 YEARS' RESULTS.

	Produce per acre in eleven years.		
	Corn 4 crops.	Wheat 3 crops.	Hay 4 crops.
	Bushels.	*Bushels.*	*Pounds.*
Caustic lime 1400 lbs. per acre applied once in 11 years	128.6	33.7	7,637
Carbonate of lime 2600 lbs. per acre applied once in 11 years	148.4	42.3	7,930
No treatment	97.5	31.9	5,200

Attempt has been made to discredit these experiments because the marl used on one of the carbonate plats *may* have contained as much as 3 per ct. potassium and .15 per ct. phosphorus. These percentages are but little higher than potassium and phosphorus are

contained in most soils, and there is no reason for supposing that in the marl they are much more available than in the soil. It has also been suggested that the oyster shells may have contained .5 per ct. nitrogen. But, even if so, its effect would have been slight and mainly confined to the first crop; whereas the plat receiving ground oyster shells gave in later years larger increases than the one receiving burned oyster shells. These objections are only begging the question and the experiment still bears testimony to the comparative value of caustic lime and carbonate of lime.

Pennsylvania experiments.— As an example of the fact that caustic lime, when applied under certain conditions or in rather large amounts, will produce injury which may more than counteract all of its good effects, we have the results of 25 years' experiments at the Pennsylvania station.

CAUSTIC LIME VS. GROUND LIMESTONE: PENNSYLVANIA EXPERIMENTS; 25 YEARS' RESULTS.

	Value of increase or decrease (—) per acre each 4 years. Rotation of corn, oats, wheat, hay.
Caustic lime, 2 tons per acre each 4 years	—1.60
Ground limestone, 4 tons per acre each 4 years	8.40

In this experiment both forms of lime are applied in larger quantities than are profitable under almost any condition. Also no special provision has been made to supply organic matter other than by the use of the clover and timothy sod. The caustic lime has not only been applied at a loss, but the crop yields from the land receiving caustic lime have been less than with no special treatment at all. On other plats in this experiment the same amount of caustic lime has been applied and in addition 12 tons of manure per acre each 4 years. The lime in this way has during the 25 years given better returns than the lime alone, although not so good as the limestone alone. But during the first eight years of the experiment the lime and manure gave lower yields than 12 tons of manure alone.

In some recent pot-culture work at the Pennsylvania station to study the growth of clover as influenced by lime in different forms and amounts, lime in different forms was compared in quantities ranging all the way from a few hundred pounds to more than 3 tons of ground limestone per acre. The following conclusions, among others, were reached from the work:

" An important fact in this extensive test is that finely-ground limestone has been fully as prompt and effective in reducing soil

acidity and promoting the growth of clover as equivalent amounts of slaked or caustic lime." (Rep't Penn. State College, 1911.)

Top dressing meadow lands.—Four years' experiments in England comparing ground lime and ground limestone for top dressing meadow lands have shown an average annual increase in hay per acre of 1650 for ground lime and 2525 pounds for ground limestone. (*Experiment Station Record* **25**:33.)

LIMESTONE VS. CAUSTIC LIME.

The results of these experiments discredit the theory that burned lime is any more effective for soil improvement than chemical equivalents of ground limestone. They further show that ground limestone is likely to produce better results on the average than burned lime. Ground limestone is safer to use, since applied in almost any quantity at any time it can have no injurious effect upon the succeeding crop nor upon the organic matter of the soil. Many instances are on record of positive injury to crops from the use of caustic lime.

Burned lime is offered to the agricultural trade in three conditions: (1) hydrated lime in sacks, (2) ground quicklime in sacks, (3) lump lime in bulk or barrels. Lime in the first two forms is usually too expensive to be considered, and it is only the bulk lump lime that comes in competition with ground limestone to any extent. The lump lime sold for $4 to $6 per ton is usually run-of-kiln and cannot be considered high grade. It must be slaked before being applied to the soil, and in practice it is very difficult to get it applied uniformly. In comparative experiments it has usually been the hydrated or ground quicklime that has been used, so as to insure the lime being applied as uniformly and as thoroughly incorporated with the soil as the ground limestone. Ground limestone is so much more agreeable to handle than caustic lime that this fact alone will usually lead the farmer to decide in its favor after he has once had experience in applying both forms.

Limestone is a neutral material and does not exert a distinct alkaline reaction excepting when in contact with an acid. Even the weakest acids easily decompose the limestone, setting free carbon dioxide and allowing the calcium or magnesium to combine with the acid, thus neutralizing it. There is thus no difficulty about the "availability" of ground limestone; if any acid is present in the soil it is easily neutralized by the limestone.

There should be no hesitancy about the use of limestone on potato land that is acid. Potato scab is favored by the absence of acid in the soil yet ground limestone does not set up the alkaline reaction that we get with burned lime. It has been shown that the potato crop is directly benefited by the use of lime carbonate where needed to correct acidity. Besides it is not profitable to require the other

crops in the rotation to grow on an acid soil for the sake of making it easier to combat scab on potatoes. In New York State the potato industry has developed on soils naturally containing lime carbonate as well as on acid soils. Also it is significant that at the Rothamsted Experiment Station, England, potatoes have been grown for 30 years successfully and with large yields on land which naturally contains as much as 30 to 50 tons of calcium carbonate per acre to the depth of the plow line. In some of our western states, notably Colorado, where the potato industry prospers and where they sometimes raise from 400 to 600 bushels per acre, the soil naturally contains from 10 to 30 tons of carbonates (limestone) to the plowed soil of an acre.

Of course in comparing different forms of lime the question of price must always be considered. And the fact that in using burned lime one has less weight to handle must also be taken into account. When the haul from the railroad station is very long and the roads rough and where ground limestone costs as much as its equivalent in burned lime, it may be more economical to use the caustic material. However, in many such instances there is some question whether lime at the present price can be used profitably. It may be better in these cases simply to grow such crops as are least sensitive to a deficiency of carbonates in the soil, to make large use of farm manure, which has some tendency to neutralize acids, and to avoid the use of those particular fertilizers that tend to increase an acid condition in the soil, such as acid phosphate and ammonium sulphate.

Good grades of ground limestone can be obtained from twelve or more producers in New York State at from \$1 to \$2 per ton in bulk, car lots, f. o. b. quarries. Throughout a large part of the state the prices at the farmers' nearest railroad station are \$1.50 to \$3 per ton; and if he will order direct from the companies, sending cash with order, he can obtain better prices than these. To equal these prices good grades of burned lime would have to sell for \$2.50 to \$5 per ton; but even then limestone would of course be preferable, because of the many other advantages given above. In some other states where ground limestone has been used more generally the prices are now much lower than here and there is every reason to believe that in the near future we shall be able to obtain it at lower figures. It can be produced at almost the cost of the coal used in burning lime. It is our greatest hope of an economical supply of lime for replenishing the soil. In view of all the facts should we not encourage the use of ground limestone in preference to that of burned lime?

FINENESS OF GROUND LIMESTONE.

The ground limestone used in the Ohio experiments was of such fineness that the total passed only a 10-mesh sieve (10 openings to the linear inch); about 60 per ct. passed a 40-mesh. Yet in these

experiments it has given fully as good results as chemical equivalents of freshly burned lime, hydrated lime, or air-slaked lime, any of which is an impalpable powder. And it should not be overlooked that the different forms have been compared in smaller quantities than give maximum results on the soil in question.

As to the limestone used in the Tennessee experiments it is stated that "nineteen per ct. was too coarse to pass through a 20-mesh sieve," which would make it about 10-mesh material.

Rhode Island Bul. 145 reports experiments showing that ground limestone was fully as effective as air-slaked lime, even for immediate results. The fineness of the limestone is not given.

Artificial (precipitated) calcium carbonate has been compared with "Limestone meal" and the latter found to give fully as good results, even for the first crop. (*Experiment Station Record*, **21**:624.)

In a comparison of crushed marble of different degrees of fineness it has been found that material passing a one-millimeter (20-mesh) sieve but coarser than a $\frac{1}{2}$ mm. (40-mesh) gave practically as good results as that finer than $\frac{1}{2}$ mm., even for the first crop. (Rep't Penn. State College, 1900.)

When limestone is ground to pass a 10-mesh sieve from $\frac{1}{3}$ to $\frac{2}{3}$ of the product will pass a 40-mesh, depending somewhat upon the nature of the stone and upon the kind of machinery used. The entire product then is about as fine as representative samples of "finely ground" bone meal, a mechanical analysis of which has been found in our laboratory to be as follows:

FINENESS OF GROUND BONE MEAL.

	Sample 1.	Sample 2.	Sample 3.
	Per ct.	*Per ct.*	*Per ct.*
Passing 10-mesh sieve	96	100	94
Passing 20-mesh sieve	82	76	71
Passing 40-mesh sieve	65	58	54
Passing 100-mesh sieve	36	32	28

Fineness in bone meal is more important than in ground limestone; for under soil conditions limestone ($CaCO_3$) is more soluble than bone meal ($Ca_3(PO_4)_2$), is used in quantities ten to twenty times as great per acre, and costs about one-tenth as much per ton. Yet bone meal of the above fineness is everywhere on the market and, excepting for its cost, is a favorite form of phosphorus fertilizer.

In humid regions limestone is leached out of the soil faster than it is reduced by cropping. Evidence on this point is furnished by the analyses of drainage waters reported from many sources. (See Hilgard's Soils, p. 22; and Hall's Book of Rothamsted Experiments,

p. 237.) Compared with other mineral constituents lime carbonate is easily soluble in soil water, especially as long as any trace of acid is present.

On the ordinary farm it is scarcely practicable nor advisable to attempt to go over all the cultivated land with an application of limestone more frequently than once in 4 to 8 years. Besides, an ordinary system of crop rotation lends itself to the practice of liming only about once in 3 to 6 years; unless, of course, the material is applied as a top dressing, which is not so effective as mixing it with the soil. Especially does this apply to alfalfa growing. The problem then is not what is the minimum amount of limestone and maximum fineness for greatest net profit the first year, but rather what quantity and fineness will give the greatest net return over a period of at least three years. If enough of 10-mesh limestone is used to last for that length of time it will, without question, give fully as good results the first year as a somewhat smaller amount of extremely fine material.

Increased fineness means increased cost and greater waste by leaching. Also limestone ground as fine as dust can hardly be handled in bulk and must be sold in sacks, which adds as much as one dollar per ton to the cost. Ten-mesh limestone, which is about the consistency of fine sand, can be readily used in bulk.

In view of all the above facts, therefore, it seems entirely unnecessary to urge that limestone be ground any finer than that the entire product pass a 10-mesh sieve and contain all the fine material produced in grinding.

HINTS ON APPLYING LIMESTONE.

Quantity to use.— Some idea as to the proper amount of limestone to use can be obtained from a consideration of the amounts that have been used in the experiments previously referred to. Also in some pot-culture studies of this subject at the Pennsylvania station it was found that the most satisfactory results were not obtained until an application was made of at least one ton per acre in excess of the amount needed to neutralize the acidity in the soil. The amount required to neutralize this acidity as determined by the method they used varied from only a few hundred pounds of limestone per acre to nearly two tons.

All things considered, the price of the limestone is one of the main factors determining what is the most profitable amount to use. It is probably not of much practical importance to determine the amount of acid in the soil as an indication of the amount of limestone to apply. The important thing to know is whether or not the soil is acid; if it is, limestone should be used liberally. But it is important to note that soils which are just beginning to be acid in the surface seven inches but still have some carbonates in the

subsoil do not need nearly as much limestone as those soils which are acid to a depth of two or three feet. Heavy clay soils usually require larger applications of limestone than sandy soils to accomplish the same result. Some crops respond more generously to heavy applications of limestone than others.

From a study of all data bearing on the subject and in consideration of the present average prices for ground limestone it seems advisable to use on most soils of this state that are distinctly in need of lime about two tons per acre of limestone as an initial application, and to follow this up with one or two tons per acre every 4 to 6 years thereafter. Under some conditions smaller amounts will do and again larger quantities would be better.

In preparing land for alfalfa it should be remembered that this crop is unusual in its requirements for lime and that for best results enough should be applied to assure the crop an abundance of that material during the succeeding four or five years. Therefore three or four tons of ground limestone per acre is probably not an extravagant amount to use in such a case.

Methods of applying.— By means of a limestone spreader is the most satisfactory way of getting this material on the land. In this manner it can be spread with much less work and the same amount will effectively cover more ground than if scattered by hand or with a manure spreader. It is best to apply the limestone to the rough ground after plowing, thus mixing it more thoroughly with the soil by the subsequent operations of disking and harrowing.

It is in the line of good practice to apply any form of lime as long as practicable before seeding the first crop to be benefited by its application. Fall plowed land furnishes an excellent opportunity for the application of limestone. Also summer plowed land to be seeded to grain in the fall and to clover or grass the following spring furnishes a good opportunity for applying limestone. In general it is much better to apply limestone in the summer and fall, when the roads are good, the land firm, and work not so pressing, rather than in the spring when there is haste to get in the crops and conditions are often bad for hauling and applying.

What soils of New York State are in need of limestone? We have as yet no maps nor complete data from which to answer this question satisfactorily. But our observations, together with those of many others who have studied the subject, lead us to believe that the great majority of the soils of the state are distinctly in need of applications of lime carbonate. The chief exceptions are those soils which overlie or are in the vicinity of extensive limestone outcrops and which are known to contain limestone gravel or boulders in the surface or subsoil.

Practical tests for the need of applying limestone.— Soils of a reddish-brown color and in the subsoil of which are occasionally found frag-

ments of limestone rock are seldom in need of liming. Soils with a light color, gray, grayish brown or yellowish shades are usually in need of liming. Whenever serious difficulty is experienced in growing good crops of common red clover, then the need of additional lime carbonate is strongly indicated. Its use may sometimes be profitable before such a condition as this is reached.

The litmus test for soil acidity is made as follows: Obtain a ball of moist soil about the size of the fist, break it open and insert a double thickness of blue litmus paper (obtainable at any drug store). Press the ball firmly together and allow to stand a half hour. If at the end of this time the paper in contact with the soil has distinctly changed to a pink color there is positive evidence of acidity in the soil and it can be safely assumed that benefit will follow liming. If there is only a very faint change of color it is not always safe to say that lime can be profitably used. If the paper remains of a deep blue color, or if perhaps the blue color is intensified, then it is not likely that limestone can be used with profit. Of course it will not do to make only a single test, but a number should be made in different parts of the field and it is better to examine the subsoil as well as the surface.

FINALLY.

It is to be understood that lime does not take the place of fertilizers and manures, but supplements them. Without sufficient lime carbonate in the soil any other treatment must fall short of its possible attainment. The benefits following its use are mild and lasting rather than phenomenal and short lived. With many crops the direct effect of an application of lime in any form does not more than pay for its cost; but its great value consists in making it possible to grow such crops as clover and alfalfa, and in greatly improving the quality and yields of meadows and pastures. It is the key to the great storehouse of nitrogen in the air. By the heavier sods and crop residues and the increased quantities of manure produced as a result of larger crops it is possible to supply the soil in a natural way not only with the nitrogen needed by plants, but with liberal amounts of organic matter which is so necessary for the liberation of mineral plant food and for good physical condition of the soil.

A list of companies in New York State producing ground limestone or marl for agricultural use is given on p. 76.

Ground limestone of good grade (the total passing a sieve with ten meshes to the linear inch, and containing at least 90 per ct. carbonates) can be obtained in bulk, carload lots, f. o. b. quarries, at $1 to $2 per ton. The added freight charges make this $1.50 to $3 per ton delivered to the farmer's railway station. For most soils in this state ground limestone should be used in liberal quantities,

and its cost ought not to exceed $3 per ton including freight. In the greater part of the state it can be obtained for much less.

Adams & Duford Co., Chaumont, N. Y.
Buffalo Cement Co., Buffalo, N. Y.
B. & B. Lime & Stone Co., Mellenville, N. Y.
Caledonia Chemical Co., Caledonia, N. Y.
Callanan Road Improvement Co., S. Bethlehem, N. Y.
Chazy Marble Lime Co., Chazy, N. Y.
Conley Stone Co., Utica, N. Y.
Cobleskill Limestone Co., Cobleskill, N. Y.
Empire Limestone Co., Buffalo, N. Y.
Harrison, John J. E., Newburgh, N. Y.
Langdon & Co., Elmira, N. Y. (quarries in Schoharie and Niagara counties).
Rock Cut Stone Co., Syracuse, N. Y.
Roberts, George H., 17 State St., New York City (quarries in Dutchess county).
Sugar River Stone Co., Booneville, N. Y.
Northern Crushed Stone Co., The, Ogdensburg, N. Y.
Upper Hudson Stone Co., 26 Cortlandt St., New York City (quarries at Verplanck Point).
Valley Stone Co., Schenectady, N. Y.
Wait, F. W., Co., Glens Falls, N. Y.
Whittleton Limestone Co., Medina, N. Y.
Worlock Stone Co., Canastota, N. Y.

Landowners in western New York should also be referred to
Carbon Limestone Co., Youngstown, O.
Bessemer Limestone Co., Youngstown, O.
Kelley Island Lime and Transport Co., Cleveland, O.

All the above references are given only as a matter of information. The Station makes no recommendations or guarantees as to reliability.

REPORT

OF THE

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TABLE OF CONTENTS.

REPORT OF THE DEPARTMENT OF BACTERIOLOGY.

A COMPARISON OF THE MICROSCOPICAL METHOD AND THE PLATE METHOD OF COUNTING BACTERIA IN MILK.*

JAMES D. BREW.

SUMMARY.

1. There is little relationship between the results obtained by the plate method and the direct microscopic method of counting bacteria in milk, when used for determining the number of bacteria in single samples of fresh, unpasteurized milk. There is, however, a relationship between the two counts when series of samples are examined. The count obtained by the microscope is almost invariably much higher and is probably the more accurate of the two.

2. The relative differences between the two counts are greater where the bacteria are few in number. In samples of milk showing plate counts of less than 10,000 per cubic centimeter, the count by the microscope shows approximately 44 times as many individual bacteria; or 17 times as many when the clumps and isolated bacteria are counted as units, individual bacteria in the clumps not being counted. In those samples which give a plate count of about 1,000,000 per cubic centimeter, the count made with the microscope shows approximately 5 times as many individual bacteria; or when the isolated bacteria and clumps of bacteria are counted as units the number of these units is slightly less than the number of colonies given by the plate method.

3. The difference between the plate count and the total number of individual bacteria according to the microscopic count is greater than the difference between the plate count and the microscopic count when the isolated bacteria and clumps are counted as individual objects. This is undoubtedly due to the fact that a colony on an agar plate develops either from a clump of bacteria or from a single bacterium.

4. In raw market milk practically all of the bacteria are alive and are adapted to growth on lactose agar incubated at 21 degrees C. when there are 1,000,000 or more per cubic centimeter.

5. The microscopic method of counting bacteria in milk has these decided practical advantages: The number of bacteria can be shown in a given sample of milk within a very few minutes. The apparatus required is less expensive than that required for the

* Reprint of Bulletin No. 373, February; for Popular Edition see p. 893.

plate method and the examinations necessary for commercial grading can be made by men who are not trained bacteriologists. The morphology of the bacteria present may be determined as well as the approximate number present. The microscope frequently shows many bacteria present in samples of milk while agar plate counts from the same samples are low.

6. For these reasons, there is hope that the method here tested, or some modification of it, can be made of practical use to the milk dealer, butter-maker and cheese-maker as a means of grading milk according to its bacterial condition. This should make it easier for the farmer to secure a better price for a high-grade milk than for a poorer grade.

7. The adoption of the microscopical method of counting bacteria in milk would involve a complete readjustment of present bacteriological standards. For this reason it is not recommended that such changes in standards be made until more comprehensive data have been secured.

INTRODUCTION.

The number of bacteria in milk is ordinarily obtained by counting the colonies which develop from an aliquot portion of a cubic centimeter of milk on nutrient agar or gelatin petri plates and multiplying according to the dilution used. Both the advantages and faults of this method are well known. The need has long been felt for some method which will give a better idea of the actual number of germs present, enable a person to secure results in a much shorter time, be simpler to use, require less expensive apparatus, and give more accurate information as to the kinds of bacteria present. There is considerable promise that the use of the microscope for examining and counting the bacteria in dried, stained films of milk will provide a method that will overcome many of the objections to the plate method without introducing other serious difficulties.

This bulletin gives the results of comparative studies between the direct microscopic method and the plate method of counting bacteria as applied to market milk. The objects of the investigation were to test the practical utility of the microscopic examination of milk and to determine whether it is a satisfactory substitute for the plate method now in general use. The author is indebted to Dr. H. A. Harding, former head of the bacteriological depart-

ment of this Station, who suggested the original plan of this work and aided in carrying it out; also to the Geneva Milk Company and the White Springs Dairy Company for courtesies shown. Acknowledgment of help received is likewise due Dr. Robert S. Breed under whose direction the work has been published.

HISTORICAL.

In the early history of the microscope, scientists conceived the idea of utilizing it as a means of counting the number of bacteria present in various substances. In fact, Leeuwenhoek, in 1683 in his earliest description of bacteria, gives an estimate of the number he saw in tartar from teeth based on what his primitive microscope revealed. A development of this technique came during the years from 1877 to 1890 during which time such men as Naegeli, Lister, Fritz, Pasteur and others used the microscope as a means of estimating the number of bacteria or yeasts present in given substances as a preliminary step in the making of pure cultures. When solid culture media were introduced and petri plates came into general use, the microscopic method of counting bacteria passed into the background and since that time the greater number of bacterial counts have been made by the plate method. So far as can be ascertained, Eberle [1] was the first to make careful determinations of the number of bacteria present in dried, stained films by the use of the microscope. In this case the films were prepared from feces. Similar quantitative studies of fecal bacteria were made later by Winterberg,[2] Klein [3] and Hehewerth.[4] MacNeal, Latzer and Kerr [5] have published the results of investigations in which the combined Eberle-Klein methods and the Winterberg method were used. Winslow [6] devised a microscopic method for quantitative

[1] Eberle, Robert. Zählung der Bakterien im normalen Säuglingskot. *Centbl. Bakt.* Abt. I, **19**: 2–5. 1896.

[2] Winterberg, Heinrich. Zur Methodik der Bakterienzählung. *Ztschr. Hyg.*, **29**: 75–93. 1898.

[3] Klein, Alex. Eine neue mikroskopische Zählungsmethode der Bakterien. *Centbl. Bakt.*, Abt. I, **27**: 834–835. 1900: Die physiologische Bakteriologie des Darmkanals. *Arch. Hyg.*, **45**: 117–175. 1902: Bemerkung zu der Arbeit Dr. Max Lissauers "Ueber den Bakteriengehalt menschlicher und tierischer Fäces." *Arch. Hyg.*, **59**: 283–285. 1906.

[4] Hehewerth, F. H. Die mikroskopische Zählungsmethode der Bacterien von Alex. Klein und einige Anwendungen derselben. *Arch. Hyg.*, **39**: 321–389. 1900.

[5] MacNeal, Ward J., Latzer, Lenore L., and Kerr, Josephine E. The fecal bacteria of healthy men. *Journ. Infect. Dis.*, **6**: 123–169, 571–609. 1909.

[6] Winslow, C-E. A. The number of bacteria in sewage and sewage effluents determined by plating upon different media and by a new method of direct microscopical enumeration. *Journ. Infect. Dis.*, Suppl. No. 1 : 209–228. 1905.

determinations of sewage bacteria, and later Winslow and Willcomb [7] made a comparative study of this and the plate method.

The first application of the microscopic method for counting bacteria in milk was made by Slack.[8] His method consisted in centrifuging 2 cubic centimeters of milk in a special rubber-stoppered tube and counting the bacteria in a stained film prepared from the slime thus obtained. Such a method is indirect and the use of the centrifuge introduces many unknown factors.

A more direct method of counting tissue cells in dried, stained smears prepared from milk was devised by Prescott and Breed [9] in 1910. This led to a publication the following year by the latter author [10] on the usefulness of the same method for counting the number of bacteria present. This method was employed in the series of investigations reported in this bulletin, the technique of which is described on page 83.

Skar,[11] in 1912, reported a method of counting bacteria in milk, apparently devised independently, which differs from the one suggested by Breed principally in the manner of staining and in allowing the fat drops to remain in the smears. He stained the bacteria by putting 0.4 cubic centimeter of carbolated methylene blue into 9.6 cubic centimeters of milk. This mixture was heated from 5 to 10 minutes not above 70° C., and then the smears were made by withdrawing 0.02 cubic centimeter by means of a capillary pipette. This milk was spread over an area of 480 square millimeters. The smears were air dried and studied without further treatment.

The latest attempt to apply the microscopic method of counting bacteria in milk has been made by Rosam [12] who places a drop of milk, and a drop of methylene blue to which has been added a little pyridin, in a spoon and heats the mixture to steaming. Then a loopful of the mixture is placed on a clean glass slide by means of

[7] Winslow, C-E. A. and Willcomb, G. E. Tests of a method for the direct microscopic enumeration of bacteria. Idem, 273–283.

[8] Slack, Francis H. The microscopic estimate of bacteria in milk. *Techn. Quart.*, **19**: 1–4. 1906: Die mikroskopische Schätzung der Bakterien in der Milch. *Centbl. Bakt.*, Abt. II, **16**: 537–538. 1906.

[9] Prescott, S. C. and Breed, R. S. The determination of the number of body cells in milk by a direct method. *Journ. Infect. Dis.*, **7**: 632–640. 1910.

[10] Breed, R. S. The determination of the number of bacteria in milk by direct microscopical examination. *Centbl. Bakt.*, Abt. II, **30**: 337–340. 1911.

[11] Skar, Olav. Eine schnelle und genaue Methode fur Zählung von Bakterien und Leukocyten. *Milchw. Zentbl.*, **41**: 454–461, 705–712. 1912.

[12] Rosam, A. Eine einfache mikroskopische Beurteilung des Gehalts der Milch an Mikroorganismen. *Milchw. Zentbl.*, **42**: 333–334. 1913.

a platinum loop of such a size that it will transfer an average of 0.004 gram of the stained milk. The area over which the mixture spreads is determined by a cover glass 18 millimeters square. The counting of the bacteria is done immediately without allowing the film to dry.

Donald[13] has made use of the microscope in the bacterial analysis of distilled water. He has devised an ingenious scheme for making pipettes which will yield uniform and accurate drops of any desired size. This method of measurement, where it can be used, will improve the accuracy of measurement employed in the direct microscopic method of counting bacteria, but is a more complicated procedure than measurement by means of capillary pipettes.

TECHNIQUE.

Microscopical method.— The microscopical method used in this work consisted in measuring out 0.01 cubic centimeter of milk taken directly from a well-shaken sample by means of a specially graduated and accurately calibrated pipette (See page 105). The drop of milk was deposited on a clean glass slide and spread over an area of one square centimeter with a stiff, straight needle. Duplicate smears of each sample were made on the same slide. The milk was then dried by gentle heat which was obtained by means of a level wooden surface over a steam radiator. Care was exercised not to allow the smears to become too hot as this made them check and thereby made satisfactory staining impossible. As soon as dry, the slides were placed for a short time in a Coplin staining jar containing xylol to remove the fat. They were then taken out and the surplus xylol about the edges of the slide wiped off with filter paper. The smears were dried and then fixed to the slide by means of a 95-per-ct. solution of alcohol. Immediately thereafter they were stained from two to three minutes in Loeffler's methylene blue, after which they were decolorized to a light blue in a 95-per-ct. solution of alcohol.

The counting was done under a 1.9 millimeter oil-immersion lens. With the particular microscope used the draw tube was placed at

[13] Donald, R. An apparatus for liquid measurement by drops and applications in counting bacteria and other cells and in serology, etc. *Proc. Roy. Soc.*, Ser. B, 86 : 198–202. 1913: A method of counting bacteria in water. *Lancet*, 184 : 1447–1449. 1913.

160 millimeters, which gave a field of such an area as to make 4,000 fields in one square centimeter and, since 0.01 of a cubic centimeter of milk was taken, then each bacterium seen in one field represented 400,000 bacteria per cubic centimeter. For careful quantitative work it was necessary to count several fields. Then if n equaled the number of fields counted and m the total number of bacteria found, the number per cubic centimeter was calculated thus:

$$\frac{400{,}000}{n} \times m = \text{Number bacteria per cubic centimeter.}$$

The factor necessary for the transformation of results to the cubic centimeter basis is not the same for all microscopes and varies in the same microscope according to the lenses used and to the length of the draw tube. It must therefore be accurately computed for each case. To do this, it is necessary to determine the radius of the microscopic field in millimeters with a stage micrometer and calculate its area by the formula πR^2. Then if x equals the area of the smear in square millimeters and if 0.01 of a cubic centimeter of milk is used, the following formula may be derived to obtain y, which is the factor necessary to transform the number of bacteria found in one field of the microscope into terms of bacteria per cubic centimeter. $\frac{x}{\pi R^2} \times 100 = y$. To simplify the calculation of the number of bacteria per cubic centimeter, it is desirable that y consist of as many ciphers as possible. Therefore it is recommended that the draw tube be so placed as to obtain some such a factor as was employed in this work: i. e. 400,000. Then, if the draw tube is always placed at this mark, the same factor can be used for all subsequent work. Convenient factors will be obtained if the length of R be 0.101 millimeter or 0.08 millimeter.

A Sedgwick-Rafter eye-piece micrometer, or similar eye-piece micrometer, is recommended for use where large numbers of bacteria are present. This is so ruled that it shows a large square sub-divided into quarters, one of which is further sub-divided. The area of the large square is different from that of the whole microscopic field and consequently the factor necessary for computation is different. The factor can be determined by a modification of the formula given above.

In comparatively fresh milk where the bacteria are few, it is more convenient to count the whole microscopic field.

PLATE I.—DRAWINGS OF MILK SMEARS AS SEEN UNDER THE MICROSCOPE

All prepared in such a way that each bacterium or tissue cell seen is equivalent to 400,000 per cubic centimeter.

GOOD QUALITY MILK.

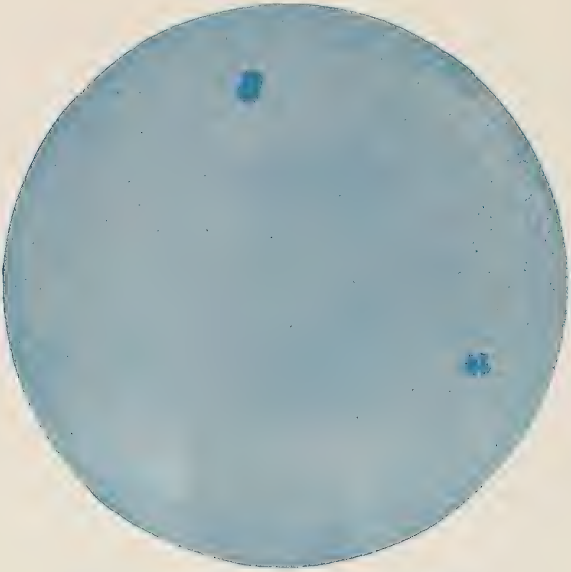


Fig. 1.—No bacteria seen. Two tissue cells. Cell count = 800,000 per c. c.

MILK SOURING NORMALLY.

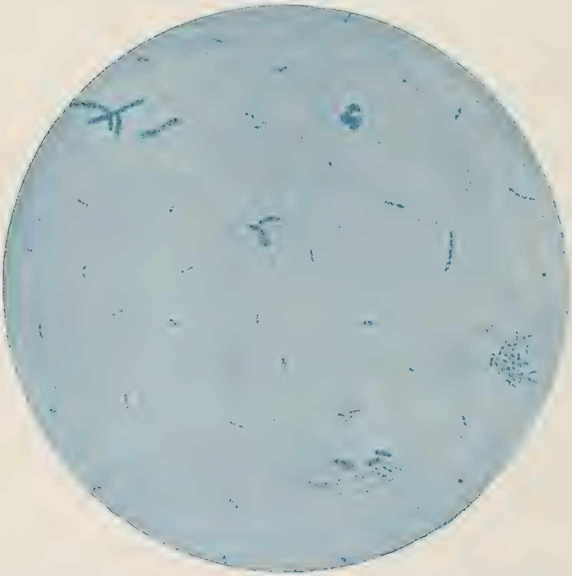


Fig. 3.—Milk which is nearly sour. The majority of the bacteria are lactic acid bacteria. One tissue cell. Bacterial count = 80,000,000 per c. c. Cell count = 400,000 per c. c.

PLATE I.—DRAWINGS OF MILK SMEARS AS SEEN UNDER THE MICROSCOPE

All prepared in such a way that each bacterium or tissue cell seen is equivalent to 400,000 per cubic centimeter.

MILK OF FAIR QUALITY.

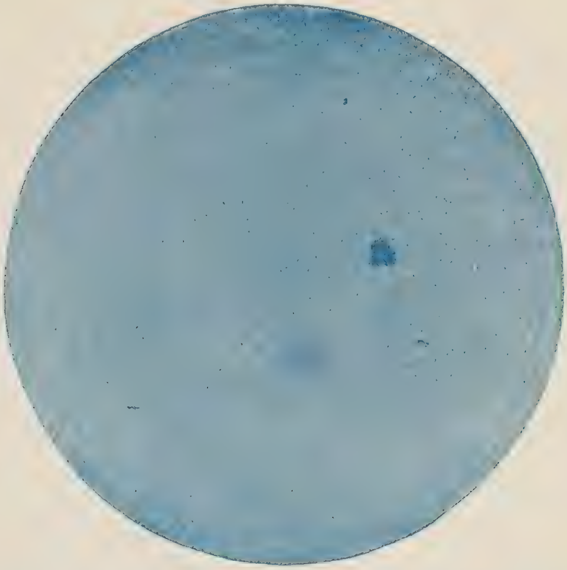


Fig. 2.—Two pairs of lactic acid bacteria and one single bacterium. One tissue cell. Bacterial count = 2,000,000 per c. c. Cell count = 400,000 per c. c.

POOR QUALITY MILK.

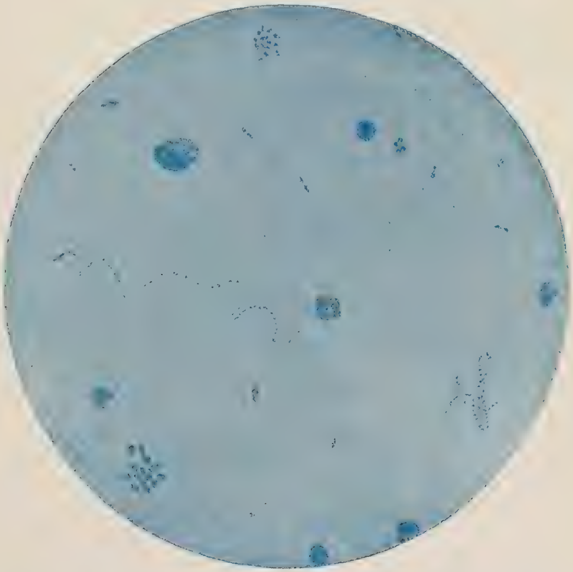


Fig. 4.— Milk which is both nearly sour and suspicious in sanitary quality. Seven tissue cells. Bacterial count = 100,000,000 per c. c. Cell count = 2,800,000 per c. c.

Plate method.— The medium used throughout these comparative tests was a lactose agar, made according to the following formula:

Liebig's beef extract...........	5 grams
Witte's peptone..............	10 grams
Agar........................	15 grams
Lactose......................	10 grams
Distilled water................	1000 cubic centimeters

The acidity was determined and adjusted so that at no time was it less than 1.3 per ct. nor more than 1.5 per ct. normal acid to phenolphthalein. The agar was distributed in test tubes in 10 cubic centimeter lots and sterilized.

Methods of sampling.— The milk used was the ordinary market milk produced for the Geneva city milk supply, and the samples were taken in the morning directly from the 40-quart cans, brought in by the farmers, as soon as they were placed on the milk-station platform. The milk was thoroughly stirred and dipped with a clean, long-handled dipper into sterilized pint bottles. In nearly every case a separate sample was taken from both morning and night milk. If the producer had several cans, then a composite sample was taken from all the cans containing milk of the same age. It usually required approximately an hour to procure the samples and bring them to the laboratory.

Smearing and plating.— The pint of milk was shaken 100 times so as to thoroughly stir up the cream and sediment and to break up the clumps of bacteria as far as possible. The making of the smears was done at once as described on page 5. Then, with a sterile pipette one cubic centimeter was transferred to a bottle containing a measured amount of sterile water, preparatory to plating. It required approximately from one-half to three-quarters of an hour to complete this part of the operation with four samples. The plating was done immediately. The dilutions used were determined somewhat arbitrarily at first, according to the conditions under which the milk was produced. Where studies of single farms were continued during a considerable length of time, the dilutions were changed according to the results secured, but an effort was made to maintain uniformity throughout. The plates were incubated at 21° C. for five days and then counted with the aid of a lens magnifying four diameters.

RESULTS.

The milk from thirty-seven dairy farms was examined. The conclusions, however, as to the comparative value of the two methods of counting bacteria were based largely on the results obtained from four of these, which were designated as Farms A, B, C and D, respectively. Examinations were made of the milk from these farms over rather long periods of time, considerable care and attention being given to the counting of many microscopic fields in each sample. Not more than one week was devoted to the study of each of the remaining thirty-three dairies and never more than five microscopic fields were counted in any sample in estimating the number of bacteria present. This latter work was more in the nature of a general survey, and was done with a view of determining the efficiency of the method where used rapidly, as it would be under commercial conditions.

The milk was delivered by the producers in 40-quart cans previously washed and steamed at the milk stations. The morning milk was from five to six hours old by the time the smearing and plating were done, while night milk was from fifteen to sixteen hours old. The following results show the bacterial content of the milk as it was delivered at the milk station, and are interesting from this point of view as well as from that of this bulletin.

Table I contains the results of comparative counts made by the two methods on seventy samples of morning milk from Farm A. The microscopic count is subdivided into three columns: The first shows the total number of individual bacteria per cubic centimeter, counting each bacterium seen. The second column shows the totals obtained when clumps and isolated bacteria were each counted as single objects. This kind of a count was made because it is generally assumed that a colony on a petri plate may originate either from a single organism or from a clump. The third column shows the number of clumps found per cubic centimeter. The last column gives the ratios between the counts given by the plate method and the counts given in the first two columns showing the results obtained by the microscopic method.

Individual cocci in diplococcus or streptococcus chains, and rod forms where the plane of division showed clearly were counted as

Table I.— Bacterial Counts of Morning Milk from Farm A.
Numbers computed for a cubic centimeter.

Date.	Agar plate counts.	Counts Under Microscope.				Ratios Between Counts	
		Total bacteria.	Bacteria and clumps.*	Clumps.	Fields counted.	A. p. T. b.	B.¶ & c.
1913.							
Jan. 30	279,000	2,138,000	408,000	184,000	100	1: 7.6:	1.4
31	93,000	2,840,000	384,000	188,000	100	1:30.5:	4.1
Feb. 3	75,000	1,340,000	280,000	108,000	100	1:17.7:	3.7
4	56,000	920,000	268,000	72,000	100	1:16.4:	4.7
5	40,000	644,000	140,000	55,000	100	1:16.1:	3.5
6	40,000	788,000	184,000	52,000	100	1:19.7:	4.6
7	50,000	324,000	76,000	48,000	100	1: 6.5:	1.5
10	32,000	1,068,000	192,000	52,000	100	1:33.4:	6.0
11	80,000	1,120,000	172,000	108,000	100	1:14.0:	2.1
13	35,000	1,660,000	160,000	84,000	100	1:47.4:	4.5
14	69,000	572,000	116,000	56,000	100	1: 8.3:	1.6
15	34,000	620,000	164,000	60,000	100	1:18.2:	4.8
17	84,000	1,232,000	196,000	124,000	100	1:14.6:	2.3
18	77,000	1,324,000	184,000	88,000	100	1:17.1:	2.3
19	99,000	1,360,000	136,000	80,000	100	1:13.7:	1.3
20	49,000	772,000	172,000	72,000	100	1:15.7:	3.5
24	75,000	1,488,000	284,000	180,000	100	1:19.8:	3.7
25	37,000	664,000	112,000	56,000	100	1:17.9:	3.0
26	49,000	388,000	100,000	40,000	100	1: 7.9:	2.2
28	36,000	2,016,000	144,000	104,000	100	1:56.0:	4.0
Mar. 3	86,000	1,564,000	144,000	104,000	100	1:18.2:	1.6
4	63,000	1,592,000	124,000	96,000	100	1:25.2:	1.9
5	79,000	880,000	124,000	92,000	100	1:11.1:	1.5
7	81,000	1,036,000	160,000	104,000	100	1:12.8:	1.9
8	32,000	1,504,000	176,000	112,000	100	1:47.0:	5.5
11	73,000	1,212,000	172,000	108,000	100	1:16.6:	2.3
12	134,000	1,908,000	196,000	160,000	100	1:14.2:	1.4
13	113,000	2,531,000	324,000	251,000	100	1:22.3:	2.8
14	130,000	2,500,000	740,000	340,000	20	1:19.2:	5.7
15	87,000	2,390,000	500,000	300,000	40	1:27.0:	5.7
17	228,000	3,890,000	430,000	330,000	40	1:17.6:	1.8
18	143,000	2,428,000	220,000	124,000	100	1:16.9:	1.5
19	300,000	11,820,000	3,900,000	940,000	20	1:39.4:	13.0
20	100,000	2,690,000	410,000	230,000	40	1:26.9:	4.1
21	84,000	2,850,000	590,000	240,000	40	1:33.9:	7.0
22	93,000	404,000	176,000	56,000	100	1: 4.3:	1.8
24	29,000	748,000	184,000	92,000	100	1:25.7:	6.3
25	†	732,000	188,000	88,000	100		
27	101,000	4,624,000	1,360,000	352,000	25	1:45.8:	13.5
28	77,000	600,000	160,000	70,000	40	1: 7.7:	2.0
31	56,000	545,000	182,000	58,000	55	1: 9.7:	3.2
April 1	102,000	851,000	145,000	87,000	55	1: 8.3:	1.4
3	92,000	669,000	169,000	87,000	55	1: 7.2:	1.8
7	62,000	292,000	101,000	42,000	75	1: 4.7:	1.6

* Each clump and each isolated bacterium counted as one; individual bacteria in clumps not counted. † Plates contaminated. ¶ These abbreviations refer, respectively, to "Agar plate counts," "Total bacteria" and "Bacteria and clumps."

TABLE I. BACTERIAL COUNTS OF MORNING MILK FROM FARM A.—continued.
Numbers computed for a cubic centimeter.

DATE.	Agar plate counts.	COUNTS UNDER MICROSCOPE.				RATIOS BETWEEN COUNTS.
		Total bacteria.	Bacteria and clumps.*	Clumps.	Fields counted.	A. p. T. b. B. & c.
1913.						
April 8	20,000	228,000	88,000	24,000	100	1:11.4: 4.4
10	29,000	148,000	80,000	16,000	100	1: 5.1: 2.7
11	33,000	1,780,000	320,000	220,000	20	1:53.9: 9.7
14	‡	684,000	124,000	68,000	100	
15	189,000	1,340,000	280,000	170,000	40	1: 7.0: 1.4
22	99,000	308,000	96,000	44,000	100	1: 3.1: 0.9
23	88,000	512,000	144,000	56,000	100	1: 5.8: 1.6
24	230,000	304,000	104,000	36,000	100	1: 1.3: 0.4
25	800,000	4,460,000	1,440,000	420,000	20	1: 5.5: 1.8
26	†	11,600,000	5,520,000	480,000	10	
29	278,000	268,000	64,000	36,000	100	1: 0.9: 0.2
30	363,000	576,000	169,000	88,000	100	1: 1.5: 0.4
May 1	717,000	11,040,000	3,400,000	1,120,000	10	1:15.4: 4.7
2	3,430,000	15,160,000	3,480,000	1,100,000	20	1: 4.3: 1.0
3	312,000	2,780,000	1,000,000	380,000	20	1: 8.8: 3.2
6	810,000	4,550,000	590,000	380,000	40	1: 5.6: 0.7
7	368,000	1,690,000	490,000	250,000	40	1: 4.5: 1.3
12	325,000	3,280,000	376,000	272,000	50	1:10.1: 1.1
13	125,000	632,000	104,000	56,000	50	1: 5.0: 0.9
14	87,000	664,000	144,000	56,000	50	1: 7.6: 1.6
16	272,000	712,000	184,000	96,000	50	1: 2.6: 0.6
17	303,000	1,624,000	368,000	224,000	50	1: 5.3: 1.2
19	237,000	9,840,000	420,000	260,000	20	1:41.5: 1.7
20	100,000	1,640,000	540,000	280,000	20	1:16.4: 5.4
23	672,000	10,000,000	1,280,000	520,000	10	1:14.8: 1.8
25	338,000	9,640,000	1,760,000	840,000	10	1:28.5: 5.2

* Each clump and each isolated bacterium counted as one; individual bacteria in clumps not counted.

† Plates contaminated. ‡ Dilution too great.

individuals. Groups consisting of two individuals were not counted as clumps.

Table II contains the results obtained from a similar study of fifty-eight samples of night milk from Farm A.

A general discussion of the results in these tables and in the following tables is given on page 97.

Where there is such a wide range between the minimum and maximum counts as is found in the individual columns of the above tables, general averages are misleading. It was therefore thought

TABLE II.—BACTERIAL COUNTS OF NIGHT MILK FROM FARM A.
Numbers computed for a cubic centimeter.

DATE.		Agar plate counts.	COUNTS UNDER MICROSCOPE.				RATIOS BETWEEN COUNTS
			Total bacteria.	Bacteria and clumps.*	Clumps.	Fields counted.	A. p. T. b. B. & c.
1913							
Feb.	18	1,327,000	11,560,000	510,000	340,000	40	1: 8.7: 0.3
	19	120,000	10,160,000	600,000	380,000	40	1:84.6: 5.0
	20	2,855,000	10,620,000	1,430,000	680,000	40	1: 3.7: 0.5
	24	1,575,000	11,940,000	1,280,000	720,000	20	1: 7.6: 0.8
	25	865,000	3,810,000	490,000	330,000	40	1: 4.4: 0.5
	26	546,000	6,280,000	360,000	240,000	40	1:11.5: 0.6
	28	6,725,000	31,650,000	6,100,000	4,100,000	8	1: 4.7: 0.9
Mar.	1	926,000	7,850,000	970,000	640,000	40	1: 8.4: 1.0
	3	1,025,000	13,130,000	750,000	540,000	40	1:12.8: 0.7
	4	2,282,000	50,800,000	11,400,000	4,950,000	8	1:22.2: 5.0
	5	1,800,000	16,780,000	1,300,000	800,000	20	1: 9.0: 0.7
	7	1,500,000	11,920,000	1,000,000	640,000	20	1: 7.8: 0.6
	8	938,000	10,600,000	800,000	520,000	20	1:11.3: 0.7
	11	9,012,000	29,640,000	7,040,000	3,060,000	20	1: 3.2: 0.7
	12	6,787,000	32,160,000	6,720,000	3,040,000	10	1: 4.7: 0.9
	13	16,962,000	57,650,000	13,600,000	5,375,000	16	1: 3.4: 0.8
	14	10,125,000	68,450,000	13,950,000	5,400,000	8	1: 6.7: 1.3
	15	6,272,000	119,900,000	17,700,000	8,100,000	4	1:19.1: 2.8
	17	3,543,000	16,530,000	1,860,000	880,000	40	1: 4.6: 0.5
	18	9,650,000	22,420,000	7,600,000	4,040,000	20	1: 2.3: 0.7
	19	12,200,000	53,100,000	12,900,000	6,600,000	4	1: 4.3: 1.0
	20	35,233,000		Milk sour			
	21	†	5,000,000	2,660,000	260,000	20	
	22	‡	870,000	230,000	80,000	40	
	24	5,800,000	29,220,000	4,260,000	1,700,000	20	1: 5.0: 0.7
	25	‡	7,320,000	580,000	370,000	40	
	27	36,650,000	129,400,000	31,600,000	15,200,000	2	1: 3.5: 0.8
	28	2,525,000	10,920,000	1,420,000	940,000	20	1: 4.3: 0.6
	31	2,600,000	5,340,000	1,000,000	560,000	20	1: 2.0: 0.3
April	1	9,825,000	23,600,000	5,850,000	2,900,000	8	1: 2.3: 0.5
	3	4,850,000	18,120,000	4,400,000	2,640,000	20	1: 3.7: 0.8
	4	41,550,000	120,200,000	32,800,000	11,800,000	2	1: 2.8: 0.7
	7	2,025,000	4,170,000	340,000	250,000	40	1: 2.0: 0.1
	10	4,500,000	5,680,000	1,140,000	580,000	20	1: 1.2: 0.2
	11	4,425,000	6,240,000	1,320,000	680,000	10	1: 1.6: 0.2
	14	8,100,000	31,800,000	5,640,000	2,640,000	10	1: 3.9: 0.6
	15	148,750,000		Milk sour			
	22	3,400,000	14,160,000	2,800,000	1,040,000	10	1: 4.1: 0.8
	23	‡	1,080,000	124,000	76,000	10	
	24	625,000	5,350,000	410,000	220,000	40	1: 8.5: 0.6
	25	2,165,000	9,440,000	1,740,000	800,000	20	1: 4.3: 0.8
	26	4,703,000	22,080,000	5,480,000	1,760,000	10	1: 4.6: 1.1
	29	1,667,000	3,420,000	380,000	300,000	40	1: 2.0: 0.1

* Each clump and each isolated bacterium counted as one; individual bacteria in clumps not counted.

† Plates contaminated. ‡ Dilution too great.

TABLE II.—BACTERIAL COUNTS OF NIGHT MILK FROM FARM A.—continued.
Numbers computed for a cubic centimeter.

DATE.	Agar plate counts.	COUNTS UNDER MICROSCOPE.				RATIOS BETWEEN COUNTS.
		Total bacteria.	Bacteria and clumps.*	Clumps.	Fields counted.	A. p. T. b. B. & c.
1913						
April 30	1,450,000	2,990,000	300,000	190,000	40	1: 2.0: 0.2
May 1	1,081,000	14,920,000	3,520,000	1,600,000	10	1:13.8: 3.2
2	10,275,000	24,320,000	9,040,000	1,680,000	10	1: 2.3: 0.8
3	15,640,000	36,200,000	10,440,000	3,400,000	10	1: 2.3: 0.6
6	10,675,000	30,440,000	7,800,000	3,840,000	10	1: 2.8: 0.7
7	5,628,000	28,720,000	5,920,000	2,440,000	10	1: 5.1: 1.0
12	267,000	4,480,000	320,000	240,000	20	1:16.5: 1.4
13	80,000	1,408,000	200,000	120,000	50	1:17.6: 2.4
14	1,090,000	5,520,000	720,000	400,000	20	1: 5.0: 0.6
16	343,000	5,320,000	440,000	300,000	20	1:15.5: 1.2
17	357,000	7,540,000	640,000	520,000	20	1:21.2: 1.7
19	650,000	10,000,000	680,000	360,000	10	1:15.3: 1.1
20	490,000	10,440,000	1,200,000	680,000	10	1:21.2: 2.4
23	460,000	6,800,000	1,720,000	880,000	10	1:14.7: 3.7
24	2,270,000	22,160,000	2,920,000	1,800,000	10	1: 9.7: 1.2

* Each clump and each isolated bacterium counted as one; individual bacteria in clumps not counted.

better to average plate counts of the same number of digits and to compare the averages of the corresponding microscopic counts with these, as is shown in Table III. The ratios were then computed between these averages using the plate count as a basis because it is generally used at the present time as the standard for quantitative bacterial analysis. Comparisons were thus made between the plate counts and the microscopic counts when the total number of individual bacteria were counted, and between the plate counts and the microscopic counts when the isolated bacteria and clumps were each counted as individual objects. The figures given in the columns which show the clump counts alone were not considered in the ratios because it was felt that there could be no constant relationship between the number of clumps and the plate count, or between the number of clumps and the total number of individual bacteria.

The milk from Farm A had a comparatively high bacterial content while that from Farms B, C and D contained few bacteria. In fact,

Table III.— Summary of Bacterial Counts of Milk from Farm A.

Numbers computed for a cubic centimeter.

Range of Agar Plate Counts.	No. samples.	Average of bacteria by agar plate count.	Counts Under Microscope.		Ratios Between Counts.
			Total bacteria.	Bacteria and clumps.*	A. p T. b. B. & c.
Morning Milk:					
10,000- 100,000.	39	63,000	1,053,000	187,000	1:16.7:3.0
100,000- 1,000,000.	27	299,000	3,965,000	768,000	1:13.3:2.5
1,000,000-10,000,000.	1	3,430,000	15,160,000	3,480,000	1: 4.4:1.1
Night Milk:					
10,000- 100,000.	1	80,000	1,408,000	200,000	1:17.6:2.5
100,000- 1,000,000.	12	549,000	7,386,000	719,000	1:13.5:1.3
1,000,000-10,000,000.	31	3,950,000	20,566,000	3,672,000	1: 5.3:0.9
10,000,000- up	8	19,260,000	64,970,000	16,517,000	1: 3.4:0.8

some of the microscopic counts from the milk of the latter farms were too low to show anything except that there were but few organisms present. Tables IV, V and VI show the counts obtained from samples taken from Farms B, C and D respectively.

Table IV.— Bacterial Counts of Milk From Farm B.

Numbers computed for a cubic centimeter.

Date.	Agar plate counts.	Counts Under Microscope.				Ratios Between Counts.
		Total bacteria.	Bacteria and clumps.*	Clumps.	Fields counted.	A. p. T. b. B. & c.
1913.		Morning Milk.				
Jan. 30	9,000	568,000	184,000	48,000	100	1:63.1:20.4
31	7,300	276,000	112,000	20,000	100	1:37.8:15.3
Feb. 3	6,000	304,000	108,000	44,000	100	1:50.6:18.0
4	2,750	176,000	116,000	28,000	100	1:64.0:42.1
5	7,000	180,000	84,000	20,000	100	1:25.7:12.0
6	3,000	120,000	108,000	....	100	1:40.0:36.0

* Each clump and each isolated bacterium counted as one; individual bacteria in clumps not counted.

TABLE IV.—BACTERIAL COUNTS OF MILK FROM FARM B.—continued.
Numbers computed for a cubic centimeter.

Date.		Agar plate counts.	Counts Under Microscope.				Ratios Between Counts.
			Total bacteria.	Bacteria and clumps.*	Clumps.	Fields counted.	A. p. T. b. B. & c.
1913			MORNING MILK.				
Feb.	7	12,000	92,000	48,000	8,000	100	1: 7.5: 4.0
	10	6,000	180,000	100,000	24,000	100	1: 30.0:16.6
	11	9,250	192,000	96,000	16,000	100	1: 20.7:10.3
	13	4,000	472,000	108,000	56,000	100	1:118.0:27.0
	14	2,750	104,000	56,000	8,000	100	1: 37.8:20.4
	15	4,250	108,000	60,000	12,000	100	1: 25.4:14.1
	17	6,870	260,000	84,000	40,000	100	1: 37.8:12.2
	18	3,250	168,000	68,000	24,000	100	1: 51.7:20.9
	19	2,700	364,000	96,000	44,000	100	1:135.0:35.6
	20	3,980	208,000	92,000	12,000	100	1: 52.2:23.3
	24	2,630	288,000	108,000	32,000	100	1:109.0:41.0
	25	5,100	128,000	32,000	16,000	100	1: 25.0: 6.2
	26	750	228,000	56,000	32,000	100	1:304.0:74.6
	28	2,400	336,000	64,000	24,000	100	1:140.0:26.6
Mar.	1	3,210	156,000	68,000	20,000	100	1: 48.6:21.1
	3	2,350	96,000	50,000	12,000	100	1: 40.8:23.8
	4	1,560	152,000	52,000	12,000	100	1: 97.4:33.3
	5	3,300	128,000	44,000	16,000	100	1: 38.7:13.3
	7	9,050	168,000	72,000	24,000	50	1: 18.5: 7.9
	8	2,500	148,000	32,000	12,000	100	1: 59.1:12.8
	11	2,560	420,000	80,000	44,000	100	1:164.0:31.2
			NIGHT MILK.				
Feb.	19	2,250	....	....	....	100	....
	20	5,250	580,000	152,000	56,000	100	1:110.4:28.9
	24	7,250	264,000	84,000	28,000	100	1: 36.4:11.5
	25	10,500	240,000	52,000	16,000	100	1: 22.8: 4.9
	26	3,250	212,000	72,000	28,000	100	1: 65.2:22.1
	28	14,000	224,000	96,000	24,000	100	1: 16.0: 6.8
Mar.	1	3,500	184,000	64,000	20,000	100	1: 52.5:18.2
	3	16,000	260,000	76,000	24,000	100	1: 16.2: 4.7
	4	6,300	116,000	64,000	12,000	100	1: 18.4:10.1
	5	15,000	140,000	36,000	12,000	100	1: 9.3: 2.4
	7	260,000	100,000	32,000	16,000	100	....
	8	6,250	104,000	40,000	16,000	100	1: 16.6: 6.4
	11	2,250	192,000	72,000	32,000	50	1: 85.3:32.0

NOTE.— In the sample of night milk taken on Feb. 19th, no bacteria could be found under the microscope.

* Each clump and each isolated bacterium counted as one; individual bacteria in clumps not counted.

TABLE V.— BACTERIAL COUNTS OF MILK FROM FARM C.
Numbers computed for a cubic centimeter.

Date.	Agar plate counts.	Counts Under Microscope.				Ratios Between Counts.	
		Total bacteria.	Bacteria and clumps.*	Clumps.	Fields counted.	A. p. T. b.	B. & c.
1913.		Morning Milk.					
Mar. 24	†	544,000	152,000	76,000	100	......	....
25	344,000	428,000	116,000	56,000	100	1: 1.2:	0.3
27	21,000	500,000	156,000	52,000	100	1: 23.7:	7.4
28	38,000	156,000	48,000	32,000	100	1: 4.1:	1.2
31	34,000	710,000	190,000	80,000	40	1: 20.6:	5.6
April 1	10,000	420,000	140,000	50,000	40	1: 42.0:	14.0
3	13,000	388,000	104,000	56,000	100	1: 29.8:	8.0
4	6,000	560,000	280,000	50,000	40	1: 90.0:	46.6
7	†	112,000	48,000	16,000	100	......	....
8	†	48,000	32,000	4,000	100	......	....
10	14,000	260,000	68,000	20,000	100	1: 18.5:	4.8
11	6,420	2,960,000	960,000	400,000	10	1:461.2:	149.5
14	12,000	104,000	56,000	8,000	50	1: 8.6:	4.6
15	17,000	288,000	101,000	43,000	75	1: 16.9:	5.9
17	9,130	325,000	91,000	27,000	75	1: 35.5:	9.9
18	5,000	283,000	123,000	32,000	75	1: 56.6:	25.6
19	6,900	164,000	52,000	24,000	100	1: 23.7:	4.3
		Night Milk.					
Mar. 24	34,000	524,000	144,000	36,000	100	1: 15.4:	4.2
25	†	3,220,000	600,000	320,000	40	1	....
27	80,000	880,000	170,000	60,000	40	1: 11.0:	2.1
28	6,000	296,000	56,000	40,000	50	1: 49.3:	9.3
31	12,000	630,000	160,000	80,000	40	1: 52.5:	13.5
April 1	40,000	428,000	75,000	28,000	85	1: 17.0:	1.8
3	9,750	600,000	120,000	52,000	100	1: 61.5:	12.3
4	5,500	310,000	160,000	30,000	40	1: 56.3:	29.0
7	†	304,000	88,000	36,000	100	......	....
8	†	240,000	88,000	16,000	50	......	....
10	9,500	235,000	101,000	27,000	75	1: 24.6:	10.6
11	†	240,000	112,000	32,000	50	......	....
14	12,000	880,000	120,000	48,000	50	1: 73.3:	10.0
15	10,000	840,000	170,000	80,000	40	1: 84.0:	17.0
17	7,330	368,000	112,000	32,000	50	1: 50.2:	15.2
18	7,250	970,000	270,000	140,000	40	1:133.7:	37.2
19	142,000	5,290,000	190,000	130,000	40	1: 37.2:	1.3

* Each clump and each isolated bacterium counted as one; individual bacteria in clumps not counted.
† Plates contaminated.

TABLE VI.— BACTERIAL COUNTS OF MILK FROM FARM D.
Numbers computed for a cubic centimeter.

DATE.	Agar plate counts.	COUNTS UNDER MICROSCOPE.				RATIOS BETWEEN COUNTS.
		Total bacteria.	Bacteria and clumps.*	Clumps.	Fields counted.	A. p. T. b. B. & c.
1913.			MORNING MILK.			
April 22	11,000	112,000	48,000	16,000	50	1:10.0: 4.3
23	2,000	144,000	48,000	16,000	50	1:72.0:24.0
24	†	144,000	48,000	16,000	50	....
25	†	740,000	210,000	80,000	40	....
26	8,700	192,000	124,000	4,000	100	1:22.0:14.2
29	15,000	48,000	24,000	8,000	50	1: 3.2: 1.6
30	15,000	40,000	40,000	....	50	1: 2.6: 2.6
May 1	5,500	192,000	56,000	24,000	50	1:34.9:10.1
3	5,400	384,000	124,000	36,000	100	1:71.1:22.9
6	21,000	568,000	128,000	64,000	50	1:27.0: 6.0
7	4,700	96,000	40,000	16,000	50	1:20.4: 8.5
8	6,200	128,000	56,000	8,000	50	1:20.6: 9.0
9	2,900	80,000	56,000	....	50	1:27.5:19.0
10	2,400	56,000	32,000	....	50	1:23.3:13.3
12	12,000	160,000	48,000	24,000	50	1:13.3: 4.0
13	8,400	56,000	40,000	....	50	1: 6.7: 4.7
14	13,000	48,000	32,000	....	50	1: 3.6: 2.4
16	16,000	360,000	104,000	32,000	50	1:22.4: 6.5
17	2,880	128,000	56,000	24,000	50	1:44.3:19.4
19	2,850	144,000	64,000	16,000	50	1:50.5:22.5
20	4,950	168,000	120,000	16,000	50	1:33.9:24.2
23	15,000	208,000	56,000	24,000	50	1:13.8: 3.0
24	34,000	256,000	128,000	32,000	25	1: 7.5: 3.7
			NIGHT MILK.			
April 22	67,000	176,000	76,000	28,000	100	1: 2.6: 1.1
23	31,000	112,000	48,000	8,000	50	1: 3.6: 1.5
24	†	232,000	72,000	16,000	50	....
25	20,000	276,000	84,000	20,000	100	1:13.3: 4.2
26	21,000	276,000	116,000	20,000	100	1:13.1: 5.5
29	17,000	88,000	24,000	16,000	50	1: 5.1: 1.4
30	16,000	176,000	48,000	16,000	50	1:11.0: 3.0
May 1	11,000	144,000	56,000	24,000	50	1:13.0: 5.5
3	10,000	296,000	112,000	32,000	100	1:29.6:11.2
6	51,000	352,000	120,000	48,000	50	1: 6.9: 2.3
7	8,500	48,000	40,000	....	50	1: 5.6: 4.9
8	7,500	104,000	72,000	8,000	50	1:13.6: 9.6
9	4,130	48,000	32,000	....	50	1:11.6: 7.7
10	5,880	56,000	48,000	....	50	1: 9.5: 8.1
12	18,000	136,000	96,000	8,000	50	1: 7.5: 5.3
13	3,000	112,000	80,000	....	50	1:37.3:26.6
14	5,380	64,000	56,000	....	50	1:11.9:10.4
16	18,000	624,000	120,000	32,000	50	1:34.6: 6.6
17	2,100	48,000	48,000	....	50	1:22.8:22.8
19	4,100	264,000	96,000	40,000	50	1:64.3:23.4
20	3,200	80,000	48,000	....	25	1:25.0:15.0
23	15,000	160,000	128,000	8,000	50	1:10.6: 8.5
24	3,100	64,000	48,000	....	25	1:20.6:15.4

*Each clump and each isolated bacterium counted as one; individual bacteria in clumps not counted.

† Plates contaminated.

Since the milk from Farms B, C and D all had a low bacterial content, the counts are combined in a general summary (Table VII) which has been drawn up in the same way that the summary for Farm A was drawn up in Table III.

Table VII.— Combined Summary of Bacterial Counts of Milk from Farms B, C and D.

Numbers computed for a cubic centimeter.

Range of Agar Plate Counts.	Number samples.	Average bacteria; plate count.	Counts Under Microscope.		Ratios Between Counts.
			Total bacteria.	Bacteria and clumps.*	A. p. T. b. B. & c.
Morning Milk:					
0– 10,000	43	5,000	215,000	84,000	1:43.0:16.8
10,000–100,000	18	18,000	262,000	84,000	1:14.5: 4.6
Night Milk:					
0– 10,000	23	5,500	231,000	62,000	1:42.0:11.3
10,000–100,000	22	25,000	357,000	97,000	1:14.3: 3.8

Table VIII.— Combined Summary of Bacterial Counts of Milk from Farms A, B, C and D.

Numbers computed for a cubic centimeter.

Range of Agar Plate Counts.	Number samples.	Average bacteria; plate count.	Counts Under Microscope.		Ratios Between Counts.
			Total bacteria.	Bacteria and clumps.*	A. p. T. b. B. & c.
0– 10,000	65	5,000	221,000	84,000	1:44.2:16.8
10,000– 100,000	79	43,000	697,000	141,000	1:16.2: 3.3
100,000– 1,000,000	41	369,000	4,734,000	723,000	1:12.8: 2.0
1,000,000–10,000,000	32	3,934,000	20,397,000	3,698,000	1: 5.2: 0.9
10,000,000– up	8	19,260,000	64,970,000	16,517,000	1: 3.4: 0.8

*Each clump and each isolated bacterium counted as one; individual bacteria in clumps not counted.

If a comparison is made between Table III and Table VII, it will be seen that the ratios are markedly similar. The chief difference occurs where the plate count is between 10,000 and 100,000 in which case the ratios in Table III are somewhat higher than the same ratios in Table VII. This is apparently due to the fact

that the average of the plate counts in this group from Farm A is higher, 63,000 bacteria per cubic centimeter, than from Farms B, C and D, 22,000 per cubic centimeter.

Table VIII shows a combined summary of all the counts from Farms A, B, C and D.

Because of the selection of counts in Table VIII the range between the maximum and minimum counts according to the plate method is limited, while no idea is given as to the maximum and minimum counts according to the microscopic method. Yet, in averaging any series of figures, this point must be considered. For this reason, the extent of the differences between the maximum and minimum microscopic counts given in Table VIII are tabulated in Table IX.

TABLE IX.— MINIMUM AND MAXIMUM COUNTS INCLUDED IN THE AVERAGES IN THE FOURTH COLUMN OF TABLE VIII.

Numbers computed for a cubic centimeter.

No. SAMPLES.	Average total bacteria.	Minimum count.	Maximum count.
65	221,000	48,000	970,000
79	697,000	40,000	2,850,000
41	4,734,000	268,000	11,820,000
32	20,397,000	2,990,000	119,900,000
8	64,970,000	24,320,000	129,400,000

COMBINED SUMMARY OF ALL SAMPLES STUDIED.

The averages obtained from the less detailed examination of samples of milk from thirty-three additional farms are combined in Table X with those from Farms A, B, C and D to show the comparative averages and the ratios between counts made by both methods on all samples studied in this investigation.

This summary of the results secured from the examination of 390 samples of milk shows practically the same ratios as those given in Table VIII, except in one instance. Where the plate count is between 10,000 and 100,000 the ratio given in Table X is noticeably larger than the similar ratio in Table VIII. In this case the total number of bacteria according to the microscopic count is about twenty-five instead of sixteen times as great. As previously stated, the microscopic counts included in this table, covering the work done on the thirty-three farms, were made more rapidly than those

on the samples from Farms A, B, C and D and this fact may possibly be responsible for the change in the ratios. No milk found among these thirty-three dairies had a plate count of less than 10,000. The important point to be noted in Table X, as in Table III, is the

Table X.— Combined Summary of Bacterial Counts of All Samples of Milk Studied by Agar Plate and Microscopic Methods.

Numbers computed for a cubic centimeter.

Range of Agar Plate Counts.	Number samples.	Average bacteria; plate count.	Counts Under Microscope.		Ratios Between Counts.
			Average total bacteria.	Average bacteria and clumps.*	A. p. T. b. B. & c.
0– 10,000	65	5,000	221,000	84,000	1:44.2:16.8
10,000– 100,000	108	43,000	1,087,000	412,000	1:25.3: 9.6
100,000– 1,000,000	122	331,000	4,064,000	849,000	1:12.3: 2.6
1,000,000–10,000,000	81	3,420,000	17,889,000	3,142,000	1: 5.2: 0.9
10,000,000– up	14	19,891,000	53,061,000	11,924,000	1: 2.7: 0.6

* Each clump and each isolated bacterium counted as one; individual bacteria in clumps not counted.

fact that a wide difference exists between the plate and microscopic counts when the bacteria are few in number and the fact that the relative difference between the counts rapidly decreases as the number of bacteria increases.

DISCUSSION OF RESULTS.

A study of the individual tables of bacterial counts reveals the existence of a certain relationship between the counts obtained by the plate method and the total number of individual bacteria per cubic centimeter according to the microscopic method, when series of counts are averaged together. Reference to Table IV shows a series of low plate counts with a correspondingly low total individual bacterial content per cubic centimeter. Successively higher counts showing similar parallels are seen on Tables V, I and II respectively. The existing parallels are, however, more striking in a long series of counts than in a short one, owing to marked irregularities in individual cases.

A more instructive comparison is shown in Tables VIII and X where the bacterial counts have been arranged and summarized

as previously described. Here it is plainly evident that a much wider discrepancy exists between the two counts where the bacterial content of the milk is low. Thus the ratios show that when the plate count averages less than 10,000 colonies per cubic centimeter the total number of individual bacteria seen with the microscope is approximately 44 times as great. The relative difference between the two counts constantly becomes less as the numbers of bacteria increase. So great is the decrease in the difference that, when the number of colonies growing on the agar plates approaches 1,000,000 per cubic centimeter, the total number of individual bacteria by the microscopic count is only approximately 5 times as great. The relative difference between the two counts appears to grow less as the counts grow still higher but too few samples of this sort were examined to warrant a positive statement.

The ratios which exist between the plate count and the microscopic count when each isolated bacterium and each clump are counted as individual objects are similar to those noted above, except that the differences between the two counts are much less. When the microscopic count is made in this way the number of bacteria per cubic centimeter is only about 16.8 times as great as the plate count when this averages less than 10,000 per cubic centimeter. The relative difference between the two counts likewise rapidly diminishes as the number of bacteria increases so that the plate count is slightly larger when milk containing approximately 1,000,000 bacteria per cubic centimeter is examined. This condition is probably explained by the fact that the colonies on solid nutrient media originate either from single bacteria or from clumps. The mechanical breaking up of the clumps in diluting the milk to prepare the petri plates causes the plate count to be slightly greater than the microscopic count under these circumstances. See Table X.

The two striking points which should be emphasized are (1) that as the numbers of bacteria in raw market milk increase the relative differences between the counts by the two methods decrease, and (2) that after the bacteria in raw market milk have increased to a certain number practically all of them grow on nutrient media when incubated at ordinary temperatures. In those cases where all of the bacteria grow, there can be no dead bacteria present.

The wide discrepancy between the two methods of counting when the numbers of bacteria are low is probably explained as follows:

Thirty-six of the sixty-five samples which showed a plate count of less than 10,000 per cubic centimeter were morning milk and presumably many of the bacteria present were derived from the udder. The temperature requirements of these organisms tend to prevent their growth on agar when incubated at 21° C. Consequently many of these udder organisms would fail to reveal themselves on the plates, while they would be seen and counted with the microscope. The remaining twenty-four samples where the plate counts were less than 10,000 per cubic centimeter were night milk, but had been kept at temperatures below 10° C. (50° F.), thereby retarding all bacterial development. Therefore, the greater part of their bacterial flora was probably of udder origin and the same explanation of the discrepancy in the count would apply.

The closer agreement between results secured by the two methods when the number of bacteria is high is probably explained in a similar way. Freshly-drawn milk contains bacteria adapted to udder conditions. But as the temperature is lowered and the milk grows older and other organisms gain access, the bacteria from the udder gradually die out or are overgrown by bacteria which thrive better at lower temperatures. Thus in such cases if the agar plates are incubated at a temperature fairly comparable to that under which market milk is usually kept, it is reasonable to expect that practically all of the bacteria will grow, and it is not surprising to find that this actually happens. It has also been observed that as the milk approaches the souring point there are proportionately more isolated bacteria and smaller clumps. This being true, then, since a colony on a plate develops from a single source, there would naturally be a closer agreement between the two counts. Even though some of the udder organisms do not grow on agar plates at 21° C. they are ordinarily so few in number as to have no appreciable effect upon the counts, except when the counts are low.

As stated, there is a general relationship between the counts made by the two methods, yet occasional very wide variations from the normal differences between the two counts are found. For example, a sample taken on February 19 (Table II) showed a plate count of 120,000 colonies per cubic centimeter while the microscopic count showed the total number of individual bacteria to be 10,160,000 per cubic centimeter. On the following day a sample was taken

which showed a plate count of 2,855,000, while the total microscopic count was 10,620,000. In other words these two samples gave widely different plate counts, while approximately the same number of individual bacteria were seen with the microscope in each sample. In the second sample referred to there were nearly twice as many clumps as in the first. This indicates that for some reason the clumps were broken apart to a greater extent in the latter case than in the former, which of course would not change the total bacterial count by the microscopic method but would result in an increased number of sources from which colonies would grow on agar. The same difference in count occurred in samples taken on February 18 and 19. In this case however the total number of clumps, and the number of isolated bacteria and clumps together, are approximately the same. The difference between the plate and microscopic counts here may also be due to the greater dissociation of the individuals of the clumps by shaking during the process of dilution in the one instance (February 18) than in the other (February 19), but a more probable explanation lies in the possibility that a certain species which did not grow well on agar was present in the sample taken February 19.

Samples were likewise found which gave approximately the same plate count but differed widely in the total number of individual bacteria present. Such an instance occurred on March 28 when a sample was taken which showed a plate count of 2,525,000 per cubic centimeter with a total individual bacterial count of 10,920,000 per cubic centimeter by the microscopic method. A sample taken March 31 gave a plate count of 2,600,000 per cubic centimeter, while the total individual microscopic count was 5,340,000. In this case, more than twice as many individual bacteria were seen by the microscope on March 28 as on March 31, but approximately the same number of colonies developed on the plates. This may be explained by the fact that species occasionally appear which tend to grow in more compact or larger clumps than others. These resist separation when shaken. Such a condition increases the total number of bacteria seen in the microscope but does not increase the number of individual objects from which colonies develop on plates.

In all of the samples studied (450) there were only three which gave a plate count higher than the total number of individual bacteria seen in the microscope. Although such counts are rare, they must

be recognized and explained. The first instance occurred among the samples reported upon in Table I, April 29, where a plate count of 278,000 and a total microscopic count of 268,000 per cubic centimeter was obtained. The second case of this kind is found in Table IV in a sample of night milk taken March 7, where a plate count of 260,000 and a microscopic count of 100,000 per cubic centimeter was obtained. The third occurred among the samples which were taken during the summer and which are summarized in Table X but not given in detail. In this case the plate count was 2,150,000 per cubic centimeter while the total number of individual bacteria by the microscope was 960,000 per cubic centimeter. In each of these three cases the duplicate plate counts agreed well and there was no evidence of contamination in any of them.

Outside of error in technique there remains another possibie explanation. Organisms may have been present which were so small that they were overlooked in the stained casein. If such a condition is the true explanation it is so uncommon as to be negligible, since there were only three samples in which it occurred.

In the work done on the thirty-three dairies which was summarized in Table X, sixty samples out of the two hundred and twenty-five were passed as having too few bacteria to count under the microscope. The corresponding plate counts of these sixty samples showed forty-two to have less than 50,000 bacteria per cubic centimeter while eight were between 50,000 and 100,000, eight between 100,000 and 200,000 and two higher than this. One of the latter was probably contaminated in the plating, as the duplicates were very irregular and gave an average count of 883,000 per cubic centimeter. Of the one hundred and twenty samples given in Tables IV, V and VI, one hundred and one showed so few bacteria that none would have been found if only a few fields of the microscope had been examined. Of the one hundred and one samples, sixty-five gave a plate count under 10,000 per cubic centimeter, thirty-four were between 10,000 and 100,000 and two above this. The average of these one hundred and sixty-one plate counts where no bacteria could be found in a few fields of the microscope was 29,000 per cubic centimeter. In other words it seems safe to assume that practically all samples passed by the microscope as having too few bacteria to count when five fields are counted would yield a plate count of less than 100,000 per cubic centimeter.

A question which naturally follows is: How many samples giving plate counts below 100,000 per cubic centimeter show microscopic fields in which bacteria can be easily and quickly seen? Out of the four hundred and fifty samples examined there were two hundred and forty-six which gave plate counts below 100,000 per cubic centimeter and sixty-seven of these gave microscopic smears in which bacteria could be readily found. In other words the plate method passed sixty-seven of the two hundred and forty-six samples as having less than 100,000 per cubic centimeter while the microscopic examination showed that they had many more bacteria than this. Thus the microscopic method is the more severe test and probably the more accurate.

It is more difficult to estimate the value of the microscopic method when applied to milk with very low counts. Many of the samples in Tables IV, V and VI are equivalent to the bacterial requirements of certified milk, averaging about 5,000 per cubic centimeter by the plate method, while the total number of individual bacteria by the microscopic count averages about 221,000 per cubic centimeter. This shows that the plate method does not reveal all the bacteria and that the extremely low counts secured by means of the agar plate count for certified milk are often misleading. The results indicate the possibility of the application of the microscopic method to counting the bacteria in certified milk, but a careful detailed count would be required. Those who have not tried it may think this a laborious operation but it is not a difficult nor a tedious task to examine as many as one hundred fields of the microscope in which only a very few bacteria can be found.

Inequality in size of clumps and varying degrees of tenacity with which different species resist separation by shaking were undoubtedly some of the unmeasurable factors which were largely responsible for the irregularities in results secured by the two methods of counting. The average-sized clump found contained from four to sixteen or twenty bacteria and clumps were frequently seen which contained as high as seventy or eighty individuals. Ordinarily little difficulty was experienced in counting all the bacteria in clumps no larger than these. Clumps were occasionally found which contained more than one hundred individuals and these frequently could not be accurately counted, especially if they were very compact. In one instance a dense clump covering more than one-half of the whole

microscopic field was seen. Since these large, compact, uncountable clumps do not appear to be common in milk they are, practically, negligible. In spite of the uncertainty in the plate counts introduced by the clumps it is interesting to note that there appears to be a fair degree of relationship between the two counts in a great number of samples, sufficiently close at least to establish a relationship between the two methods when long series of counts are compared.

In discussing the irregularities which occur between the two counts the question of dead bacteria must be considered. There is little reason for believing that there are many dead organisms present in fresh, unpasteurized milk excepting possibly some udder species which die off at low temperatures. These are so few in number as to be of no consequence. This fact is substantiated by the results obtained. Moreover, it is well understood that normal fresh milk is such a favorable medium for bacterial life that practically all bacteria thrive in it, or at least exist in an inactive state until so many are present that overcrowding occurs. Then, of course, many are killed. As previously stated, none of the samples taken were more than fifteen hours old and therefore all may be regarded as fresh milk. Where market milk is produced under variable conditions and is continually subjected to contamination, it might occasionally become inoculated with bacteria which do not grow well in milk. In such cases there might be enough dead bacteria to cause appreciable variations between the counts obtained by the two methods, but this would be rare. This might be what actually happened in the sample taken on February 19 (Table II). There is no proof, however, that this is the explanation of this particular discrepancy between the two counts. This much can be said, that the microscopic method shows more accurately the total number of living and dead bacteria present in all samples. The number of bacteria, whether dead or alive, is indicative of the past history of a given sample of milk and of the danger of contamination to which milk has been exposed.

It is known that dead bacteria do not stain as well as living ones and that they soon disappear as stainable objects. The exact effect which the dead bacteria in pasteurized milk would have upon the microscopic count, or how efficiently the microscopic method would determine the bacterial quality of pasteurized milk, is as yet unknown.

A DISCUSSION OF THE ADVANTAGES AND DISADVANTAGES OF THE MICROSCOPIC AND PLATE COUNTS.

The advantages and disadvantages of these two methods have been tabulated in Table XI and a brief discussion of the more important points follows.

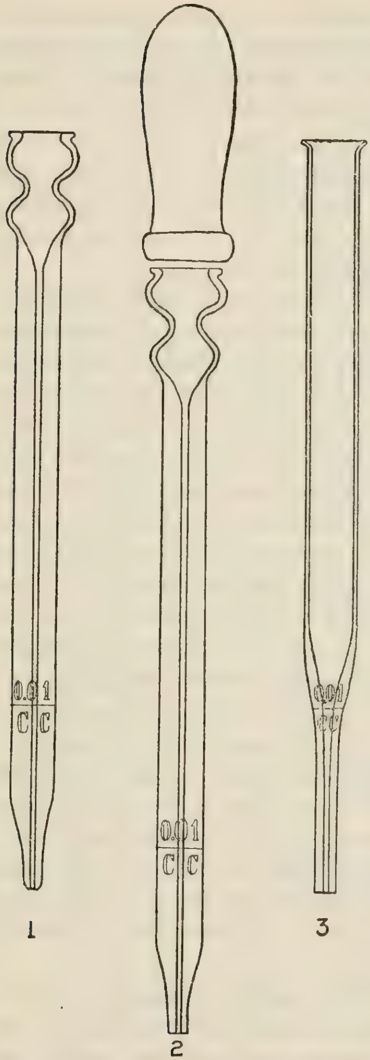
TABLE XI.— THE ADVANTAGES AND DISADVANTAGES OF THE DIRECT MICROSCOPIC METHOD AS COMPARED WITH THE PLATE METHOD.

DISADVANTAGES.

Direct microscopic method.	Plate method.
1. Difficult to measure so small a quantity of milk accurately.	1. All bacteria do not grow on the plates because of changes in food, temperature relations, or other conditions of environment.
2. The sample measured is too small to be representative.	2. The difficulty of breaking up the clumps in the milk affects the accuracy of the count.
3. Dead bacteria may be counted.	3. Requires from 2 to 5 days' incubation period.
4. Error of count is great where bacteria are very few or many.	4. Different species require different incubation temperatures.
5. Cannot be used for quantitative work when the bacteria are few in number.	5. Gives no idea of the morphology of the organisms present.
6. Many fields must be counted, because of the uneven distribution, if an accurate count is required.	6. More apparatus required, therefore more expensive. Technique complicated and difficult for trained bacteriologists to use in such a way as to secure consistent results.
7. Large, compact clumps cannot be counted.	
8. Bacteria may be lost in process of preparing slides.	

ADVANTAGES.

Direct microscopic method.	Plate method.
1. Less apparatus required, therefore less expensive. Technique simple.	1. Is necessary for isolation of pure cultures.
2. The results on a given sample can be reported within a few minutes.	2. Gelatin shows the liquefiers and, if litmus is used, the acid-producing bacteria.
3. Shows the cell content, the presence or absence of streptococci and other important things necessary in estimating the sanitary quality of milk.	3. Shows character of growth.
4. Gives a better idea of the actual number of germs present.	4. Shows living organisms only.



CAPILLARY PIPETTES USED IN THE MICROSCOPIC METHOD OF COUNTING BACTERIA IN MILK.

Form of pipette.— Three different forms of pipettes * were tried but the one which gave the most satisfactory results was the straight-bored, square-tipped pipette shown in Fig. 2.

This pipette is slightly different from the one originally figured by Breed, which was similar to Fig. 1. The objection to the latter pipette is that the beveled tip causes the milk to run back on the outside of the pipette in such a way as to make it difficult to deposit the whole drop. This does not happen if the tip is squared as in Figs. 2 and 3. Fig. 3 shows another form in which the bore is slightly widened near the graduation mark. This feature saves time because it is difficult to stop the meniscus in a straight bore at the desired point. This form of pipette has one objection, however, in that the wider the bore the greater the chance of error in measurement, but, on the whole, this pipette is almost if not quite as satisfactory as the one shown in Fig. 2.

Error in measurement of sample.—It is difficult to measure quantities as small as 0.01 of a cubic centimeter accurately with capillary pipettes. The

* Since the above was written a new form of pipette has been devised by Dr. Breed which is more satisfactory than any of those figured. It can be obtained of Bausch and Lomb Optical Co.

weighing of a few samples from different pipettes demonstrates, however, that the error is ordinarily due more to faulty graduation and form of tip than to the inability to measure successively quantities which weigh approximately the same. This is shown in Table XII which gives the weights of several samples of milk obtained from different pipettes, together with the percentage error. The computation of this error is based upon the specific gravity of milk as 1.032. The percentage error of the same pipettes as determined by calibration with mercury is also given.

Pipettes A, B and C were straight-bored with square tips (See Fig. 2). Pipettes D and E were straight-bored with beveled or rounded tips (See Fig. 1). The tip of pipette D was, however, so slightly rounded that no difficulty was experienced in depositing the whole drop of milk. Pipette F was the one shown in Fig. 3. Evaporation of milk during weighing may have caused some of the irregularities in the weights given, but this error must have been practically the same in all cases. One thing shown by these figures is that it is unwise to trust to the calibration of such pipettes by commercial firms. The tests indicate that capillary pipettes such as these should be so calibrated with mercury as to have an error of approximately plus 5 per ct. in order to deliver the correct amount of milk (.0103 grams). Pipette C was the one chosen for use in the present investigation.

Small samples not representative.— Objection has been raised to the studying of so small a sample of milk because of the possibility that it will not be representative of the whole. Table XIII shows counts made on three samples of milk, from each of which four duplicate smears were prepared and counted, which indicate that this is not a serious error. These three samples are typical of a large series of duplicate microscopic counts which have been made. The irregularities are no greater than those found in duplicate counts made by the plate method.

Few or many bacteria.— The error of count is greater where there are only a few organisms present, because it is easily possible to overlook some. The finding of one organism or the failure to find one organism means a difference of several thousand in the final count, the exact amount depending upon the number of fields counted. If an accurate count must be made on such samples then it is necessary to count a large number of fields. Under ordinary circumstances it is not necessary to do this, for it is soon seen that the sample con-

Table XII.— Relative Accuracy of Different Pipettes for Taking Small Samples of Milk.

COMPARATIVE WEIGHTS OF 0.01 CUBIC CENTIMETER SAMPLES OF MILK.

Pipette A.		Pipette B.		Pipette C.		Pipette D.		Pipette E.		Pipette F.	
Weight samples.	Error.	Weight samples.	Error.	Weight samples.	Error.	Weight samples.	Error.	Weight samples.	Error.	Weight samples.	Error.
Grams.	*Per ct.*	*Grams.*	*Per ct.*	*Grams.*	*Per ct.*	*Grams.*	*Per ct.*	*Grams.*	*Per ct.*	*Grams.*	*Per ct.*
.0102	.97	.0100	2.91	.0102	.97	.0064	37.86	.0046	55.33	.0094	8.73
.0102	.97	.0102	.97	.0098	4.85	.0066	35.92	.0050	51.45	.0080	22.33
.0092	10.60	.0104	.97	.0100	2.91	.0064	37.86	.0044	57.47	.0098	4.85
.0102	.97	.0102	.97	.0094	8.73	.0062	39.80	.0050	51.45	.0086	16.50
.0104	.97	.0102	.97	.0102	.97	.0061	40.77	.0050	51.45	.0090	12.63
.0102	.97	.0102	.97	....	....	.0056	48.56	....	....	....	....
.0100	2.91	.0102	.97	....	....	.0060	41.74	....	....	....	....
.0102	.97	.0098	4.85	....	....	....	....	....	....	....	....

PERCENTAGE ERROR OF PIPETTES WHEN CALIBRATED WITH MERCURY.

Pipette A.	Pipette B.	Pipette C.	Pipette D.	Pipette E.	Pipette F.
+6.5	+4.7	+4.8	—25.0	—33.5	—3.7

TABLE XIII.— TYPICAL COUNTS SHOWING NUMBER OF INDIVIDUAL BACTERIA AND CLUMPS FOUND IN MICROSCOPIC FIELDS OF SMEARS FROM THREE SAMPLES OF MILK.

Sample No. 1. Twenty-five fields counted on each smear			
Smear 1.	Smear 2.	Smear 3.	Smear 4.
1	0	4 (1)	0
4 (1)	0	0	0
6 (1)	4 (1)	1	8 (1)
1	0	0	10 (1)
1	1	0	0
0	0	6 (1)	4 (1)
33 (3)	0	0	0
0	15 (1)	8 (1)	0
8 (1)	9 (1)	4 (1)	0
8 (1)	0	6 (1)	8 (1)
0	0	0	22 (1)
0	0	0	0
0	22 (2)	2	2
10 (2)	0	11 (1)	2
0	2	0	0
0	0	0	6 (1)
6 (1)	1	0	8 (1)
0	0	22 (1)	4 (1)
0	6 (1)	4 (1)	3 (1)
0	10 (2)	0	2
18 (2)	0	0	0
0	4 (1)	2	0
4 (1)	19 (2)	1	4 (1)
3 (1)	8 (1)	4 (1)	2
0	6 (1)	2	0
103 (14)	107 (13)	77 (9)	85 (10)
1,618,000	2,120,000	1,232,000	1,390,000

Average number of bacteria per c. c.—1,488,000

Sample No. 2. Ten fields counted on each smear.			
Smear 1.	Smear 2.	Smear 3.	Smear 4
2	12 (3)	11 (2)	122 (4)
18 (1)	6	2	12 (2)
4 (1)	10 (1)	124 (1)	6 (1)
4 (1)	12 (2)	42 (5)	12 (1)
10 (1)	7 (1)	19 (1)	3 (1)
39 (1)	8 (2)	66 (2)	14 (1)
4 (1)	35 (5)	7 (1)	13 (2)
32 (3)	10 (2)	96 (2)	12 (1)
53 (3)	17 (3)	7 (1)	172 (2)
4 (1)	17 (1)	10 (2)	13 (2)
170 (13)	134 (20)	384 (17)	379 (17)
6,800,000	5,360,000	15,630,000	15,660,000

Average number of bacteria per c. c.—10,740,000

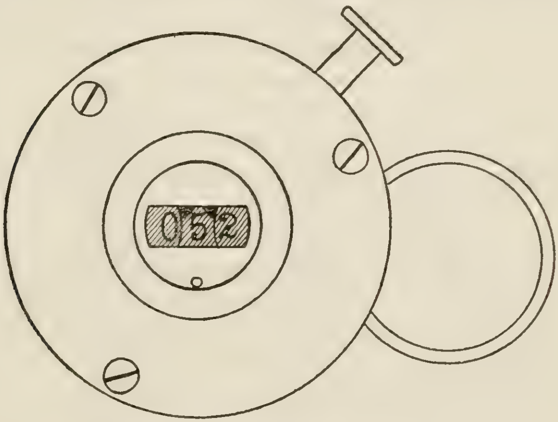
Sample No. 3. Ten fields counted on each smear.			
50 (2)	32 (2)	0	42 (1)
168 (2)	14 (1)	4 (1)	2
0	18 (2)	5	0
8 (2)	11 (2)	11 (1)	15 (2)
0	20 (2)	228 (1)	0
8 (2)	18 (2)	34 (2)	1
35 (1)	0	75 (1)	0
8 (1)	1	4 (1)	13 (1)
6 (1)	27 (1)	0	137 (2)
11 (2)	10 (1)	0	0
294 (13)	151 (13)	361 (7)	210 (6)
11,760,000	6,040,000	14,440,000	8,400,000

Average number of bacteria per c. c.—10,160,000

NOTE.—Figures in parenthesis indicate the number of clumps of 3 or more individuals.

tains very few bacteria and the precise count makes little difference. If there are many bacteria present in the smear it is often impossible to count the whole field of the microscope, owing to confusion caused by lack of guide lines. An eye-piece micrometer, ruled in squares, overcomes this difficulty. Here, too, it is not necessary to count a large number of fields, for it is soon seen that the milk is of poor quality.

Uneven distribution.— A more real source of error than the agreement or lack of agreement between duplicate counts is the uneven distribution of bacteria in the smear. It is evident that for accu-



Benton Hand Tally Register.

rate quantitative work several fields must be counted to overcome this error. This is a laborious operation if large numbers of bacteria are present. Fortunately practical experience has shown that accurate counts are not necessary in order to form a satisfactory idea of the amount of bacterial growth which has taken place in a given sample of milk. Counting is much more easily done if a hand tally register is used. This can be procured from hardware dealers.

Counting of the whole field.— Another error which becomes important in some cases lies in attempting to count the whole microscopic field. The margin of the microscopic field is invariably so hazy as to obscure the bacteria lying in this region. This error is not serious, however, where few organisms are present, but becomes

serious in the case of fields containing large numbers of bacteria. The use of the micrometer referred to above obviates this difficulty.

Dead bacteria.— Dead bacteria may be counted. In normal fresh milk however, there is every indication that they are a negligible factor, as previously explained.

Large clumps.— Even though all bacteria in compact clumps cannot be counted, such clumps occur so infrequently that they may be regarded as unimportant.

Cells and streptococci.— Thus far the sanitary significance of tissue cells and streptococci is still a matter of discussion. They are both readily seen and counted. This point is discussed in detail in Bulletin No. 380 of this Station.

Loss of bacteria.— The question whether bacteria are lost in the preparation of the slides is discussed on page 111.

TWO OTHER DIRECT MICROSCOPIC METHODS OF MILK EXAMINATION.

Skar's method.— This method of making milk smears differs from that used in these investigations in that the stain is put directly into the milk as described on page 82 and the smear is dried and studied without washing, or dissolving out the fat. This procedure was planned in order to avoid all washing of the smears which, it was feared, would remove some of the bacteria. The principal aim in making a study of this method was to determine whether this possibility was a real one, because at first thought it appears to be perfectly reasonable. Comparisons were made between various smears prepared from milk having a high bacterial content. The resulting counts are given in Table XIV, and show the total number of single bacteria per cubic centimeter, the clumps having been disregarded.

An examination of these results shows that while there is some irregularity in the counts, there is ordinarily a markedly lower count obtained from Skar's smears than from Breed's smears made from the same sample of milk. Unquestionably, this is due to the fact that the fat globules in the Skar smear are so numerous as to completely hide many bacteria from view. This does not prove, however, that Skar's fear that the bacteria are carried away in the removal of the fat is groundless. Nevertheless, a study of the two right hand columns of figures, secured from counts made on smears where Breed's method was so modified that 0.02 of a cubic

centimeter of milk was taken and spread over an area of 24 x 20 millimeters and compared to Skar's smear from which the fat was removed, indicates that this contention is not true.

To further determine whether the bacteria were lost in the washing process, a drop of milk stained by Skar's method was dried in one concavity of a clean, double, hollow-ground slide and treated for some time with xylol. Then the xylol was carefully allowed to run over into the second concavity and evaporated. Examination under the microscope failed to reveal any bacteria. This operation was repeated with ether, but no bacteria could be found. This, together with the counts made, shows that if any bacteria are removed in the process of preparing the slides the number is so few as to be of little or no importance.

Table XIV.— Comparative Counts Obtained by the Skar and Breed Methods

Sample No.	Breed smear, 0.01 c.c. milk spread over 1 sq.cm.	Skar smear, 0.02 c.c. milk spread over 4.8 sq. cm.	Breed smear, 0.02 c.c. milk spread over 4.8 sq. cm.	Skar smear, fat removed by xylol.
1	601,400,000	288,960,000	660,960,000	879,840,000
2	1,842,000,000	1,656,000,000	2,054,000,000	1,666,000,000
3	421,000,000	182,000,000	397,000,000	362,500,000
4	496,000	209,000	289,000	544,000
5	3,725,000	1,974,000	2,472,000	3,371,000
6	2,077,000	1,349,000	1,746,000	1,862,000
7	863,000	762,000	2,167,000	1,425,000
8	9,869,000	13,650,000	12,690,000	....
9	2,810,000	3,150,000	4,500,000	....
10	448,800,000	174,720,000	649,920,000	....
11	372,400,000	458,880,000	589,440,000	....
12	106,200,000	31,275,000	....	....
13	60,000	none	none	....

Rosam's method.— A description of the technique of this method is given on page 82. Table XV gives the results of a few comparative counts.

Table XV.— Comparative Counts Obtained by the Rosam and Breed Methods.

Rosam method.	Breed method.
137,480,000	601,400,000
none	863,000
60,000,000	172,000,000
149,000,000	412,000,000
165,000,000	564,000,000

It should also be stated that several samples which showed only a few bacteria according to the Breed method showed no bacteria at all by the Rosam method. The chief difficulty with this technique is due to evaporation at the edge of the cover glass, which causes diffusion currents. These currents oftentimes move so rapidly as to sweep the bacteria completely out of the microscopic field while they are being counted. The bacteria in many preparations could not be counted for this reason. Another difficulty came from heating the mixed milk and stain to steaming. This caused the formation of a film on the surface of the milk, which had to be removed. It was impossible to determine how many bacteria were removed at the same time. Another objection to the method which cannot be overloooked is that there is a wide variation in the weight of the loopfuls taken. The technique calls for a platinum loop of such a size that it will transfer an average of 0.004 gram of milk and stain mixture. Even for rough work the percentage variation between loopfuls ought not to be great, but when series of weighings were made a very wide variation was found even when all possible precautions were taken to make the weights uniform. The following were the weights secured from different loopfuls of milk measured by the same loop.

First Trial — Milk Stained with Loeffler's Methylene Blue.	Second Trial — Milk Stained with Methylene Blue and Pyridin.
0.0070 grams.	0.0026 grams.
0.0044 "	0.0032 "
0.0052 "	0.0024 "
0.0064 "	0.0046 "
0.0068 "	0.0050 "
0.0043 "	0.0045 "
0.0055 "	0.0023 "
0.0053 "	0.0025 "
0.0061 "	0.0029 "
0.0053 "	0.0027 "
0.0065 "	0.0039 "
0.0052 "	

It is difficult to say how much these variations in weight were due to evaporation which occurred during the process of weighing. The rate of evaporation is obviously high in thin films of warm milk. An attempt was made to keep the interval of time of each weighing the same, and as small as possible, in order to keep the error from this source constant. In spite of this there is a percentage variation

of about 50 per ct. Such variations in the amount of milk taken make a serious error in the final computation.

In addition to these objections, the Brownian movement of stained particles in the milk occasionally makes it difficult to distinguish them from the smaller bacteria. Rosam's preparations must be examined at once as they are not permanent. This is also an objection in practical work where it is often impossible to count the bacteria at once, particularly if many samples are being inspected.

The value of a similar method of making milk preparations as a means of counting tissue cells has been known since 1905, when Doane and Buckley [14] suggested a method of staining and making slides, preferable in both respects to the method suggested by Rosam.

PRACTICAL APPLICATION OF MICROSCOPIC METHOD OF EXAMINING DRIED MILK SMEARS.

It is impossible to say definitely how much practical use can be made of the microscopical examination of dried and stained milk smears. Further investigations must be made to show whether the results here obtained agree with those found by other investigators working under different conditions. Thousands of counts must be made before the usefulness of the method can be fully established.

Other questions of great importance which remain unsolved in any satisfactory way are: How rapidly do dead bacteria undergo dissolution in milk? Can they be distinguished from living ones by means of stains or other technique? These questions must be answered before the technique can be used in a practical way for the examination of pasteurized milk, or for milks where so large a number of bacteria have developed that many have died from one cause or another.

All that can be said is, that this technique is one which shows much promise under the conditions where it has been tried. It is a means whereby milk dealers, butter-makers and cheese-makers can quickly determine the exact bacterial condition of a given sample of milk. In all of these cases it is hoped that it will serve a double purpose: First, to enable a farmer who really produces

[14] Doane, Charles F. Leucocytes in milk and their significance. Md. Agr. Exp. Sta., Bul. 102, 1905.

a clean, high-grade milk to secure the highest price, and, second, to enable milk dealers, butter-makers and cheese-makers to select their high-grade milk and separate it from that of inferior quality.

Apparently the method has a greater usefulness in this way than it has where samples are to be examined the history of which may be unknown. Until the value of this method for the examination of pasteurized milk is determined it will be uncertain as to how much use can be made of it in the examination of samples of this sort where some are pasteurized and others not.

The improvement of market milk supplies is primarily an economic question which involves the grading of milk and the paying of a better price for that of high grade.[15] The microscopic method of milk examination will aid in bringing this about because it permits the establishment of grades involving a bacterial standard more readily than the plate method. There are two grades into which milk can be divided naturally by this method, each being separated from the other by a fairly distinct border line. One includes those samples of milk in which bacteria cannot be seen readily after searching through a few fields of the microscope and which usually give a plate count below 100,000 per cubic centimeter. The other includes those samples in which bacteria can be seen readily in a few fields of the microscope and which ordinarily give a plate count above 100,000 per cubic centimeter. There are no other natural points by which more grades can be established and any such grades must be arbitrarily fixed by more extensive investigation and by practical experience. The basis for these statements is found in the results discussed on pages 97 to 104.

CONCLUSIONS.

There appears to be a thoroughly well defined relationship existing between the direct microscopic count and the plate count. This is more apparent in long series of examinations than in short series because of wide variations between results secured by the two methods on single samples. The relation between the two counts is so variable in individual samples that it is impossible to establish

[15] Harding, H. A. Publicity and payment based on quality as factors in improving a city milk supply. N. Y. Agr. Exp. Sta., Bul. 337, 1911: Harding, H. A., and Brew, J. D. The financial stimulus in city milk production. N. Y. Agr. Exp. Sta., Bul. 363, 1913.

a definite ratio whereby the results obtained by the one method can be interpreted on the basis of the other method. This makes it impossible to determine with a reasonable degree of certainty just what dilution to use in making plates, if it is desired to supplement the microscopic work with a cultural study.

A much wider relative difference exists between the two counts where the bacteria are few in number than where they are are numerous, with a rapidly decreasing difference as the numbers of bacteria increase. This is not only true in a comparative series of counts but it holds true for many individual samples. When the plate count averages less than 10,000 per cubic centimeter the total number of individual bacteria as seen by the microscope is about 44 times as great, but when the plate count approximates 1,000,000 per cubic centimeter the total number of individual bacteria is only about 5 times as great. The difference, however, between the plate count and the microscopic count where each isolated bacterium and clump is regarded as an individual object is much less, being only about 17 times as great as the plate count when this averages less than 10,000 per cubic centimeter. The two counts are practically the same when the plate count approximates the 1,000,000 mark. This clearly indicates that the bacteria found in unpasteurized market milk containing 1,000,000 or more bacteria per cubic centimeter practically all grow on nutrient agar media if incubated at ordinary temperatures.

These facts demonstrate that the bacterial count obtained in milk by the direct microscopic method is equally as good if not a better criterion of its bacterial content than the count obtained by the plate method. Whatever may have been the cause of such variations as those cited on page 100, it is unquestionably true that the microscope reveals the actual germ content of such samples as the one taken on February 19 (Table II) more accurately than does the plate count. Since the number of bacteria present in a given sample of milk is indicative of the care and of the contaminating influences to which the milk has been subjected, the plate method failed in this particular case to reveal what it is generally supposed to reveal. In other words the plate count gives the idea that this particular sample of milk was of a much better quality than those taken on February 18, 20 and 24 from the same farm, while the microscope shows that this was not true.

In spite of the limitations of the microscopic method it possesses these advantages: In some samples it shows the presence of bacteria not adapted to growth on gelatin or agar; the results can be obtained within a few minutes from the time the sample is taken; the initial expense for apparatus and equipment is less than that required for the plate technique and the depreciation very slight; a technically trained man is not essential as is the case where the plate method is used.

The microscopic method of milk examination has its limitations as well as the plate method, and the limitations of the two methods are such that the one supplements the other. For commercial work with unpasteurized market milk the microscopic method for determining bacterial quality shows promise of greater usefulness than the plate method.

CELLS IN MILK DERIVED FROM THE UDDER.*

ROBERT S. BREED.

SUMMARY.

1. Cells of two entirely different kinds are discharged in the milk of all cows throughout the entire lactation period. The larger number of the cells are leucocytes (white blood corpuscles) while a smaller number are epithelial cells, nuclei or other fragments of such cells. The epithelial cells here referred to are apparently the same as the colostral corpuscles of the majority of earlier writers.

2. The evidence thus far obtained indicates that the largest average number of cells occurs in colostral milk but equally large numbers of cells occasionally occur in milk drawn at any time during the lactation period. Several very high cell counts have been obtained from the milk of animals nearing the end of the lactation period, and the evidence here given indicates that such high counts are more common during the latter part of the period than during the height of lactation, but the average cell counts for the latter part of the period do not seem to be markedly higher than the average cell counts for the earlier part of the period.

3. There are marked daily variations in the number of cells discharged, the cause or causes of which have not yet been discovered. No constant relationship holds between the number of cells discharged in the foremilk and the number discharged later in the milking process. There is a constant increase in the number of cells discharged in the strippings, the cause of which is not yet clear. The four quarters of the udder do not act as a unit in the discharge of the cells but show as wide variations in number and character of the cells discharged as do separate udders.

4. Of 122 cows whose milk has been examined, 59 gave cell counts under 500,000 per cubic centimeter, 36 gave counts between 500,000 and 1,000,000 per cubic centimeter, and 27 gave counts over 1,000,000 per cubic centimeter. The average cell count was 868,000 per cubic centimeter.

5. The investigations here carried out have not demonstrated what relationship exists, if any does exist, between the number of

* Reprint of Bulletin No. 380, March; for Popular Edition see p. 900.

cells discharged and specific bacterial infections of the udder. Such being the case, it is impossible to decide whether or not the discharge of large numbers of cells or of specific kinds of cells in connection with streptococci or other bacteria has any sanitary significance.

6. Considerable changes in the amount of vacuum used to operate cow milkers were found to be entirely without effect on the cell content of the milk. Several things seem to indicate that the number of cells present in milk drawn by a machine operated by the use of a vacuum is somewhat less than the number present in hand-drawn milk. The results obtained show that there is no reason for thinking that changes in the vacuum or that high vacuums may in themselves cause the discharge of excessive numbers of cells or that high vacuums may draw blood from the interior of the udder.

7. The method of preparing dried milk smears here used has been found to give excellent results. It is a comparatively simple method to use and has the added advantage that the smears so prepared can be used for counting the bacteria present as well as the cells. The conclusion formulated in earlier papers, that none of the results obtained by previous investigators who have determined the number of cells by counting them in centrifuge sediments are accurate enough to be of value other than to show general conditions, has been entirely substantiated in the present investigation.

INTRODUCTION.

Normal milk is a secretion which shows large numbers of small fat drops in it when viewed under the microscope. Among these fat drops there may be seen certain cells derived from the udder of the cow. The exact nature of these cells is still disputed by some but there can be little doubt that the majority of them are leucocytes (white blood corpuscles) which have made their way into the milk from the lymph or blood of the cow. Others of these cells, less in number, are epithelial in nature; that is, they are worn-out secreting cells of the udder itself.

The number of these cells in milk is discussed at length in a paper by Breed and Stidger [1] where the following conclusion is reached:

[1] Breed, R. S., and Stidger, I. R. The number of cellular elements in milk. *Jour. Inf. Dis.*, 8 : 361–385, 1911.

"The number of cellular elements in cows' milk varies from numbers so few as to be almost negligible (less than 5,000 per cubic centimeter) to 20,000,000 and more per cubic centimeter in milk which we have good reason for calling normal."

The hygienic significance of the cells has been much discussed because of the fact that many men have felt that the presence of large numbers of leucocytes is an abnormal thing and therefore undesirable. It has also been generally believed that there is a close relationship between the presence of pathogenic streptococci of the kind that cause mastitis, and large numbers of body cells. Milk containing large numbers of cells has therefore been frequently condemned as unhealthful food. Moreover, because of the fact that milk clarifiers remove these cells from the milk in large numbers, the question has been raised whether this removal may not be an advantage.

It therefore becomes an important question to the dairy farmer to know whether there is any justification in fact for these beliefs and statements. This bulletin gives the results of some investigations which have been made in order to secure more information concerning the nature and significance of the cells.

All of the determinations of the number of cells in milk have been made by means of a comparatively new method of milk examination which is discussed in detail in Bulletin 373 of this Station. The latter bulletin likewise discusses the usefulness of this microscopical method of counting objects in dried, stained films of milk as applied to bacteria, while the present bulletin shows the usefulness of the method as a means of determining the cellular content of the milk.

ACKNOWLEDGMENTS.

The writer is under special obligations to Dr. H. A. Harding, former head of the Bacteriological Department at this Station, for his courtesy in having placed the facilities of the laboratory at the writer's disposal during February and March, 1911, at which time he was on leave of absence from Allegheny College. The work reported here was largely accomplished during this time. Throughout the study, Dr. Harding maintained a lively interest in it and aided materially in planning some of the experimental work. Special acknowledgment of help rendered is also due Mr. G. A. Smith,

Dairy Expert at the Station, who has courteously placed the records of the Station herd at the author's disposal. The completeness of these records adds greatly to the value of the work. Mr. J. K. Wilson, former Assistant Bacteriologist at the Station, Mr. G. L. Ruehle, Assistant Bacteriologist at the Station, and Mr. I. R. Stidger and Mr. F. C. First, former Assistants in Biology at Allegheny College, have all helped in the work. Credit is given to them for this help in the body of the paper.

PRESENT STATUS OF THE QUESTION OF THE HYGIENIC SIGNIFICANCE OF THE BODY CELLS IN MILK.

It has long been known that many of the secretions of the human body contain cells discharged from the tissues of the body, and that these cells are in general of two kinds: (a) Epithelial cells discharged either from the secreting portions of the glands or from the lining of ducts or general epithelial surfaces, and (b) leucocytes which make their way through the walls of the capillaries and the lymphatics into the epithelial layers which form the secretion of the gland and thus, finally, into the secretion itself. Under certain pathological conditions the discharge of these cells may increase greatly above the normal amount.

Under normal conditions, the secretion of the sebaceous glands, which lie at the roots of the hairs of mammals, is entirely composed of disorganized cells which in this case are of an epithelial nature. The saliva in the mouth commonly contains leucocytes together with numerous cells discharged from the epithelial lining of the mouth and the salivary glands. Cellular debris from a variety of sources occurs in urine under normal conditions.

It has likewise been known since 1837 [2] that colostral milk contains certain cellular bodies called colostral corpuscles. These corpuscles have usually been regarded as detached epithelial cells, although some have claimed them to be leucocytic in nature. It is ordinarily stated that these colostral corpuscles disappear from the milk within a few days.

During the period from 1837 to 1900 and later, numerous investigators studied the histology of the mammary gland and the processes of milk secretion. Many of these investigators found that cells

[2] Donné, A. Du lait et en particulier de celui des nourrices. Paris, 1837.

or cell fragments were present in the secretion of the gland as it was first formed in the alveoli but few of them studied milk itself to see whether the cells were discharged or not. Recent workers among these histologists have nearly all recognized the dual nature of the cells, the best statement of the modern view in regard to them which has come to the attention of the author being found in a new book by Ernst [2a] received while the present paper was in press.

No particular attention had been attracted to the presence of cells in milk itself until Stokes and Wegefarth [3] called attention to the presence of leucocytes in market milk. They distinguished these from the epithelial cells in the milk by the form of their nuclei. The method which they used for obtaining the cells for examination was to centrifuge a given quantity of milk from individual cows. A practically constant amount of the slime thus secured was removed by the use of a platinum loop and smeared on a slide, dried, stained, and examined under an oil-immersion lens. When more than five leucocytes per field were found, they considered the milk unfit for use. Throughout their earlier papers, they speak of leucocytes as " pus " cells, an unfortunate use of the word which has been kept up by many writers. Leucocytes occur normally not only in blood vessels and in lymphatic tissues and vessels, but also make their way out of these into almost all of the other tissues of the body. Thus their mere presence in milk, even in large numbers, does not justify the use of the term " pus " cell except where they are shown to have the significance of pus cells. Attention was immediately directed to the presence of the cells thus interpreted as "pus" cells and other investigators took up the work of devising better methods of counting them and of establishing definite numerical standards by means of which normal milk could be distinguished from abnormal milk. Both the method of counting the cells and the numerical standard suggested by Stokes and Wegefarth have been shown to have little value, but their work was of great importance because it directed attention to the universal presence of cells in milk and raised the question of their sanitary significance.

[2a] Ernst Wilhelm. Grundriss der Milchhygiene für Tierärzte. Stuttgart, 1913.

[3] Stokes, W. R., and Wegefarth, A. The microscopic examination of milk. *Med. News*, 71 : 45–48, 1897. Idem, *Jour. State Med.*, 5: 439, 1897. Idem. Ann. Rpt. Health Dept. Baltimore for 1897, pp. 105–111.

This method of milk examination was later improved by Bergey,[4] Stewart [5] and Slack.[6] The final improved form of the Stokes method is commonly spoken of as the "smeared-sediment" method of milk examination. It has been generally used in a number of American laboratories for routine examinations, and is recommended by the Committee on Standard Methods of Bacterial Milk Analysis [7] appointed by the American Public Health Association.

About the same time Doane and Buckley [8] devised a modification of the ordinary method used in counting the number of red and white blood cells which they used for counting the cells in milk. In this so-called "volumetric" method, 10 cubic centimeters of milk was centrifuged and a suspension prepared from the sediment obtained. This suspension was examined in the counting chamber of a Thoma-Zeiss haemocytometer and the cells counted. The cell counts thus obtained proved to be higher than those obtained by the use of the smeared-sediment method.

This "volumetric" method was later modified by Russell and Hoffmann [9] who found that a preliminary heating of the milk to 70 degrees C. enabled them to secure higher and more consistent counts. This modified form of the "volumetric" method is recommended by the Committee on Standard Methods already referred to as being more accurate but less convenient to use for routine work than the smeared-sediment method.

A number of American investigators have used one or both of these methods to determine the number of cells present in milk and an extended discussion of their sanitary significance has been carried on. Some of the papers which have been written have already been referred to. Other papers are those of Ward, Henderson and

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[4] Bergey, D. H. The cellular and bacterial content of cows' milk at different periods of lactation. Univ. of Penn. Med. Bul., 17 : 181–182, 1904. Idem. Source and nature of bacteria in milk. Dept. Agri. Commonwealth Penn., Bul. 125: 1–40, 1904.

[5] Stewart, A. H. Methods employed in the examination of milk by city health authorities. *Amer. Med.*, 9 : 486–488, 1905.

[6] Slack, F. H. Methods of bacteriological examination of milk. *Jour. Inf. Dis.*, Supple. 2 : 214–222, 1906.

[7] *Amer. Jour. Pub. Hyg*,. 20 (N. S. 6) : 315–345, 1910.

[8] Doane, C. F. Leucocytes in milk and their significance. Md. Agr. Exp. Sta., Bul. 102 : 205–223, 1905.

[9] Russell, H. L. and Hoffmann, C. Effect of heating upon the determination of leucocytes in milk. *Amer. Jour. Pub. Hyg.*, 18 (N. S. 4) : 285–291, 1908.

Haring,[10] Harris,[11] Russell and Hoffmann,[12] Bergey,[13] Kendall,[14] Pennington and Roberts,[15] Miller,[16] Stone and Sprague,[17] Campbell,[18] Hastings, Hammer and Hoffmann,[19] Jordan,[20] Heinemann, Luckhardt and Hicks,[21] Lewis,[22] Ross,[23] Scannell [24] and others.

In 1910, Prescott and Breed [25] suggested a method of counting these body cells in milk directly without the use of the centrifuge. In this method, stained smears of a small drop of milk (0.01 cubic centimeter) were made on an area of one square centimeter and the cells counted by means of an oil-immersion lens. By the use of this "direct" method they showed that the number of body cells in milk was much greater than had been supposed. They found that, in centrifuged samples such as had been used by previous investigators, a large and variable number of cells rose with the cream and so did not appear in the sediment. They also found

[10] Ward, A. R., Henderson, M., and Haring, C. M. The numerical determination of leucocytes in milk. State Bd. Health Calif., 19 Biennial Rpt., 142–156, 1906.

[11] Harris, N. MacL. The relative importance of streptococci and leucocytes in milk. *Jour. Inf. Dis.*, Supple. 3, 50–62, 1907.

[12] Russell, H. L., and Hoffmann, C. Leucocyte standards and the leucocyte content of milks from apparently healthy cows. *Jour. Inf. Dis.*, Supple **3** : 63–75, 1907. Idem. Distribution of cell elements in milk and their relation to sanitary standards. Wis. Agr Exp. Sta., 24 Ann. Rpt., 231–253, 1907.

[13] Bergey, D. H. The leucoctye and streptococcus content of cows' milk. Univ. Penn. Med. Bul., 20 : 106–109, 1907.

[14] Kendall, A. I. The significance and microscopical determination of the cellular contents of milk. Coll. Stud. Res. Lab. Dept. Health N. Y. City, **3** : 169–181, 1907.

[15] Pennington, M. E., and Roberts, E L. The significance of leucocytes and streptococci in the production of a high-grade milk. *Jour. Inf. Dis.*, **5** : 72–84, 1908.

[16] Miller, W. W. The significance of leucocytes and streptococci in milk. U. S. Pub. Health and Mar. Hos. Serv., Bul. 56 : 491–498, 1912 (Reprint from Bul. 41, 1908).

[17] Stone, B. H., and Sprague, L. P. Some studies of the physiological leucocyte content of cows' milk. *Jour. Med. Res.*, **20** (N. S. **15**) : 235–243, 1909.

[18] Campbell, H. C. Leucocytes in milk. U. S. Dept. Agr., Bur. An. Ind., Bul. 117 : 1–19, 1909.

[19] Hastings, E. G., Hammer, B W., and Hoffmann, C. Studies on the bacterial and leucocyte content of milk. Wis. Agr. Exp. Sta., Res. Bul. 6 : 189–218, 1909.

[20] Jordan, J. O. Protection of public milk supplies from specimens contaminated with pus organisms. *Amer. Jour. Pub. Hyg.*, **19** (N. S. **5**) : 126–134, 1909; **20** (N. S. **6**) : 601–604, 1910.

[21] Heinemann, P. G., Luckhardt, A. B., and Hicks, A. C. On the production of sanitary milk. *Jour. Inf. Dis.*, **7** : 47–66, 1910.

[22] Lewis, D. M. Practical municipal milk examinations. *Jour. Amer. Pub. Health Assn.*, **1** : 778–782, 1911.

[23] Ross, H. E. The cell content of milk. Cornell Agr. Exp. Sta., Bul. 303 : 775–793, 1911. Idem. *Jour. Inf. Dis.*, **10** : 7–16, 1912.

[24] Scannell, J. J. Some practical considerations on the presence of leucocytes and streptococci in milk. *Amer. Jour. Pub. Health*, **2** : 962–970, 1912.

[25] Prescott, S. C., and Breed, R. S. The determination of the number of body cells in milk by a direct method. *Jour. Inf. Dis.*, **7** : 632–640, 1911.

that the ratio of variation between the counts obtained by the smeared sediment and the direct methods varied from 1: 2 to 1 : 41. Later Breed [26] showed that the precipitation of the cells in centrifuges and separators depended on the speed of revolution and that in gravity-raised cream practically all of the cells rise with the cream. Other uncontrollable factors make it impossible to obtain any constant proportion of the cells in centrifuge sediments. Later studies of whole milk smears by Breed and Stidger [27] showed that only the general conclusions which had been obtained by the use of the methods of counting where the cells had been counted in the sediments obtained by centrifuging were of value. By the use of the new technique it was demonstrated that many more cells were present in normal milk than had previously been thought to occur. Moreover it was shown that the previous work which had claimed to demonstrate that a relationship exists between the discharge of large numbers of these cells and streptococci was inconclusive. The real reason or reasons for the discharge of the cells was not discovered.

English sanitarians have also been interested in the problems which have arisen concerning the number and significance of these cells. The first paper found which refers to them is one by Eastes [28] in which he discusses their sanitary significance. In 1906, Savage [29] devised a method of counting the cells which was practically identical with the one devised independently by Doane and Buckley [30] already referred to. His method has been somewhat modified by Hewlett, Villar and Revis [31] who have made extensive studies concerning the number and nature of the cells in milk.

So far as known, no investigator from continental Europe has become interested in determining the number of body cells present

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[26] Breed, R. S. Die Wirkung der Zentrifuge und des Separators auf die Verteilung der Zellelemente in der Milch, nebst einer Kritik der zur Bestimmung der Zellenzahl in der Milch verwendeten neuen Methoden. *Arch. Hyg.*, 75 : 383–392, 1911.

[27] See footnote 1.

[28] Eastes, G. L. The pathology of milk. *Brit. Med. Jour.* for Nov. 11, 1899, 1341–1342.

[29] Savage, W. G. Streptococci and leucocytes in milk. *Jour. Hyg.*, 6 : 123–138, 1906.

[30] See footnote 8.

[31] Hewlett, R. T., Villar, S., and Revis, C. On the nature of the cellular elements present in milk. *Jour Hyg.*, 9 : 271–278, 1909. 10 : 56–92, 1910. 11 : 97–104, 1911; 13 : 87–92, 1913.

in milk, although many investigators have taken up the study of the nature of these cells either because of their sanitary significance or because of their connection with the processes of secretion. The most important of the recent papers examined are those of Michaelis,[32] Lenfers,[33] Winkler,[34] and Ernst.[35] These papers deal largely with the histology of the udder and the physiology of milk secretion and give extensive bibliographies by means of which other papers dealing with these questions can be found. A recent paper by Skar [36] discusses the relation of these cells to the presence of reductase.

The results of these investigations may be summarized as follows:

1. Normal milk contains a variable number of tissue cells which are probably of two kinds: (a) Leucocytes (white blood corpuscles) which have passed through the epithelial lining of the alveolus. Under normal conditions these are not pus cells any more than leucocytes in the lymph and blood, saliva and other secretions are pus cells. (b) Cell debris derived from the epithelial lining of the alveoli and ducts of the udder consisting of nuclei and other fragments of cells, and entire cells.[37]

2. These tissue cells are practically absent in the milk of some cows but are normally present in the milk of the majority of cows in numbers which may reach into the hundreds of thousands or millions per cubic centimeter.

3. Free epithelial nuclei and single epithelial cells are apparently found frequently. Rarely groups of epithelial cells may be found just as they were discharged from the lining of the alveolus.

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[32] Michaelis, L. Beiträge zur Kenntniss der Milchsecretion. *Arch. Mikr. Anat. u. Entwickl.*, **55**: 711–747, 1898.

[33] Lenfers, P. Zur Histologie der Milchdrüse des Rindes. *Ztschr. Fleisch- u. Milchhyg.*, **17**: 340–350, 383–390, 424–429, 1907.

[34] Winkler, W. Die Milchbildung und die mikroskopische Milchprüfung. *Ztschr. f. Landwirtsch. Versuchsw. Oesterreich*, **11**: 562–630, 1908.

[35] Ernst, W. Ueber Milchstreptokokken und Streptokokkenmastitis. *Monatsh. f. prakt. Tierheilk.*, **20**: 414–435, 498–518, 1909, **21**: 55–89, 1909.

[36] Skar, O. Verhalten der Leukozyten der Milch bei der Methylenblau-Reductaseprobe. *Ztschr. Fleisch- u. Milchhyg.*, **23**: 442–447, 1913.

[37] The strongest opponents of the idea that some of these cells are leucocytes are Winkler and Hewlett, Villar and Revis, all of whom believe that the cells in milk are of epithelial origin. The evidence which they produce to support their views is far from convincing when carefully analyzed. Their interpretation of the nature of the polynuclear cells as epithelial is so unusual that it needs much more conclusive evidence before it can be accepted.

4. When cream is allowed to rise by gravity, practically all of the cells adhere to the fat drops and are carried up into the cream layer. Separators and centrifuges precipitate a variable proportion of these cells and under some conditions may precipitate nearly all of them.

5. On account of this variable action of centrifuges, no method of determining the number of the cells based on the examination of sediments obtained in this way can give accurate quantitative results. Such a method as the "smeared-sediment" method is convenient to use for obtaining material for qualitative examination but is of little value as a means of determining the number of cells present. High cell counts obtained by this method indicate the presence of large number of cells in the milk but low counts may be due either to the failure of the centrifuge to precipitate or to a low cell content of the milk.

6. Strippings contain a larger number of cells than milk from the earlier part of the milking. The variation in the number of cells in the milk discharged from the four quarters of the udder is almost as great as the variation in the number of cells discharged in the milk of different cows. Individual cows show considerable variation in the number of the cells from day to day. The cause or causes and significance of these fluctuations are as yet unknown.

A great deal of the confusion which has arisen in the discussion over the nature of these cells and their hygienic significance has been due to the assumption made by many investigators that the presence of the cells under any conditions is a pathological phenomenon and therefore undesirable. Many other contradictions have come about because of the use of inaccurate methods of counting the cells and in careless interpretation of results. The chief reason why histologists are so far apart in their interpretation of the nature of the cells is because they have not fully realized the extent of individual variations and the consequent need of obtaining material from a variety of animals whose previous history was known so far as cell content of their milk was concerned. Histological material from normal udders secured when they are secreting their maximum quantity of milk is also very difficult to obtain, and few men have ever studied such material. Moreover the interpretation of the minute histological differences in the structure of the cells requires careful technique and great care to avoid misinterpretations.

PLAN AND PURPOSE OF THIS INVESTIGATION.

It has been the purpose of this investigation: (1) To make a number of examinations of the milk of individual animals in order to determine the normal number of cells present in the milk. These studies are supplementary to those made by Breed and Stidger.[38] (2) To make detailed examinations of the milk of individual cows in the hope that some reason could be discovered for the known variations. (3) To study the influence of the milking machine on the number of the cells present in the milk.

The animals whose milk was examined were largely from the Station herd. This herd is of especial interest because the records of the animals have been well kept so that their history is known. Moreover, part of the herd was milked by machine and part by hand. This gave an excellent chance to do experimental work to determine the influence of machine milking on the cell content of the milk.

The Station herd consisted of 25 full blood and nearly full blood Jerseys at the time these examinations were made. The herd was free from tuberculosis but, in spite of careful management, was not free from troubles due to abortion and sterility. The stabling of the cows was excellent and the herd as a whole free from udder troubles. No three-teated cows were in the herd and only three whose record shows a history of udder troubles of any kind. [Chloe B. (No. 7), Hammond F. 2 (No. 16), and Millie of Geneva (No. 19).] During the six weeks in which a majority of these tests were made, the author of this paper was present at all but a few milkings and kept a careful watch for gargety milk but discovered none.

Records of the animals studied are given in Table I so far as they are pertinent to this investigation. Other records of some of these cows are given in Bulletin 322 of the Station.

The animals whose names are printed in the table in bold face type are registered full blood Jerseys. The "Hammonds" are also believed to be full blood Jerseys, but are not registered. The others are grade Jerseys.

Gerty F. 2 (No. 12), Millie D. of the Station (No. 18) and Ruth F. (No. 24) were the animals used in the experiment with the increased vacuum and Gerty F. 1 (No. 10), Hammond F. 1 (No. 15), and

[38] See footnote 1.

Mabel S. F. (No. 17) were the controls used in this experiment. Their cases are discussed in detail in pages 156–159 and 171–2.

Carey Fairy (No. 5) has the habit of sucking herself, thus causing her poor records.

Carey F. B. B. (No. 6) did not calve in 1911. Her milk after October 29, 1911, and before her next lactation period is not included in the total given for 1912.

TABLE I.— RECORDS OF STATION HERD.

Bold face type indicates full blood Jerseys.

No.	NAME OF COW.	Born.	Age in 1911.	Date of Calving in Year		Milk Yield in Last Complete Lactation Period Previous to		
				1910–1911.	1911–1912.	Feb. 1, 1911.	Feb. 1, 1912.	Feb. 1, 1913.
			Yrs.			*Lbs.*	*Lbs.*	*Lbs.*
1	Anna G.	Apr., 1904	7	Sept. 8, 1910	Sept. 7, 1911	6,920	6,808	4,093
2	**Carey of the Station**	Feb., 1903	8	June 1, 1910	July 7, 1911	3,502	7,194	2,836
3	**Carey of S. B. B**	May, 1908	3	Oct. 12, 1910	Oct. 16, 1911	......	5,464	6,206
4	**Carey of S. F.**	Mar., 1907	4	Dec. 12, 1910	Feb. 14, 1912	6,369	6,589	7,513
5	**Carey Fairy**	May, 1906	5	Aug. 7, 1910	Aug. 29, 1911	3,694	7,112	5,183
6	**Carey F. B. B**	July, 1908	3	Oct. 29, 1910	Aug. 4, 1912	......	4,756	4,479
7	Chloe B.	Aug., 1906	5	Feb. 11, 1910	Mar. 3, 1911	6,778	Sold	......
8	Dolly F. B. B.	May, 1908	3	July 7, 1910	Aug. 1, 1911	......	6,318	4,785
9	**Dotshome Carey**	Dec., 1900	11	July 8, 1910	July 6, 1911	4,657	8,001	4,065
10	Gerty F. 1.	April, 1905	6	July 19, 1910	Aug. 14, 1911	7,382	5,666	6,832
11	Gerty F. 1. B. B.	April, 1908	3	Oct. 29, 1910	Nov. 21, 1911	......	5,232	6,779
12	Gerty F. 2.	May, 1906	5	Aug. 4, 1910	Aug. 27, 1911	7,518	5,570	9,854
13	Gerty F. 3.	July, 1907	4	July 7, 1910	Aug. 4, 1911	5,106	8,027	4,300
14	Hammond 2.	——, 1899	12	Sept. 16, 1910	Sold	6,746	9,446	Sold
15	Hammond F. 1.	May, 1906	5	Aug. 27, 1910	Sept. 25, 1911	6,895	5,587	8,070
16	Hammond F. 2.	May, 1907	4	Dec. 12, 1910	Dec. 27, 1911	7,174	8,021	7,018
17	**Mabel S. F.**	Nov., 1905	6	June 6, 1910 Oct. 28, 1910	See notes	4,400	Sold	......
18	**Millie D. of the Station**	Mar., 1902	10	May 31, 1910	Oct. 16, 1911	7,595	5,666	7,828
19	**Millie of Geneva**	May, 1903	9	Sept. 18, 1910	Twin calves, Sept. 6, 1911	2,719	5,704	5,559
20	**Millie F.**	July, 1904	7	Nov. 23, 1910	Dec. 3, 1911	8,175	2,348	9,371
21	**Millie F. B. B**	Aug., 1906	5	Jan. 12, 1910	Jan. 14, 1911	5,344	5,347	7,421
22	Nora D.	May, 1903	8	Jan. 17, 1911	Sold	8,492	6,961	Sold
23	Nora F. B. B.	Oct., 1908	3	Jan. 1, 1911	Sold	......	Sold	......
24	Ruth F.	Mar., 1906	5	May 26, 1910	June 26, 1911	7,217	6,683	7,934
25	Ruth F. B. B.	April, 1909	2	....	Mar. 12, 1911	......	Sold	......

Chloe B (No. 7) at the end of her 1910 lactation period developed an abscess between the quarters of her udder, which healed leaving a hard lump. This lump was still plainly evident at the time of her calving in 1911 but had entirely disappeared before she was sold in November, 1911. See pp. 144–152.

Dolly F. B. B. (No. 8) aborted her first calf on July 7, 1910, but her second and all later calvings have been normal.

Gerty F. 3 (No. 13) aborted her first calf on May 5, 1909. Other calvings have been normal.

Hammond F. 2 (No. 16) had an attack of so-called "spider in the teat" in her right hind quarter during her 1912–13 lactation period.

Mabel S. F. (No. 17) aborted her first calf on September 10, 1907. This was followed by two normal calvings, after which she aborted again (October 28, 1910). This accounts for the two calvings reported for 1910. She continued to give a small amount of milk until the end of May when she was dried off and sold.

Millie of Geneva (No. 19) suffered from so-called "spider in the teat" in her left hind quarter in her 1910 lactation period, thereby causing her poor record for that year. The teat healed but was thereafter difficult to milk because of a partial obstruction of the duct. See pp. 157–160.

Millie F. (No. 20) met with an accident during her 1910 lactation period, which caused her to abort at eight months (November 23, 1910). She was seriously sick at the time but recovered and is now one of the best cows in the herd.

Ruth F. (No. 24) suffered from milk fever in June, 1911.

Ruth F. B. B. (No. 25) aborted her first calf at eight months in 1911 and was sold soon after. See pp. 152–153.

In addition to the studies made of the animals in the Station herd, a single examination was made of the milk of each of the animals in a herd of 53 registered Guernseys owned by Mr. A. G. Lewis of Geneva. Records of this herd are given on pages 134–5. Table XII in Technical Bulletin No. 27 of the Station gives a record of the kinds of bacteria present in the udders of the same cows.

METHOD USED IN THE EXAMINATION OF THE MILK.

The method used in counting the cells was the direct microscopical method first suggested for this purpose by Prescott and Breed [39] and later used by Breed [40] for counting bacteria in milk. The technique of this method as carried out in this work has been practically the same as that used in the earlier investigations.

[39] See footnote 25.

[40] Breed, R. S. The determination of the number of bacteria in milk by direct microscopical examination. *Centbl. Bakt.*, Abt. II, 30 : 337–340, 1911.

The counting of the cells was done under an oil-immersion lens where the area of the field was 0.0002 of a square centimeter.[41] This is obtained by adjusting the tube length of the microscope until the diameter of the field as measured by a stage micrometer is 0.16 millimeters. The need of making this adjustment carefully should be emphasized because of the careless way in which several previous investigators have referred to the field of an oil-immersion lens as if it had a standard size. With all oil-immersion lenses it is easily possible to secure fields much larger or much smaller than the one designated by using different tube lengths and different oculars.

The distinctness with which the cells show makes it possible to use the whole field of the microscope even though the edge of the field is hazy and indistinct.

In all except a few of the counts here given, one hundred fields of the microscope were counted on each of the duplicate smears and the results so obtained averaged together. The number thus obtained multiplied by 5,000 gave the number of cells per cubic centimeter. All of the smears were made and counted by the author himself unless otherwise noted.

Samples were ordinarily taken from the pail of milk just as the milking was completed, after careful stirring. The samples were then taken to the laboratory at once and the smears made before the cream began to form. All samples were thoroughly shaken at the time the smears were made in order to prevent a concentration of the cells at the top.

I. CELL CONTENT OF NORMAL MILK.

A. CELL CONTENT OF THE MILK OF THE ANIMALS IN THE STATION HERD.

When the study of the cell content of the milk of the animals in the Station herd was started, a preliminary examination was made of samples taken as described above on the evenings of February 10, 13 and 14, 1911. The results of these tests are given in the column of Table II which bears the caption "Count No. 1." After this

[41] An unfortunate error crept into the first paper giving an account of this method by Prescott and Breed (see footnote 25) where we state (page 634, l. 14) that the area of the field covers approximately 0.005 sq. cm. This should read 0.0002 or 1/5000 sq. cm. Fortunately the remaining portion of the calculation is printed correctly so that the error is readily detectable.

preliminary survey, detailed studies of individual cows were undertaken. These are given in later tables.

The remaining cell counts given in Table II were secured from smears made from samples of milk taken monthly for the determination of the butter fat in the milk of individual cows. These butter fat samples were taken by the regular milkers in the following way: Half pint bottles were half filled at the evening milking and allowed to stand in the milk house over night; the next morning these bottles were filled from the morning milking and the samples taken to the laboratory.

The smears for the cell counts were made from these samples by the author on February 27 and March 23, 1911. After that time, it became necessary to entrust the making of the remaining smears to Mr. Wilson. The results obtained from counting these smears are unsatisfactory in some respects because of the fact that it was difficult to break up the cream clots which formed in the samples in standing over night. It is probable that some of the high counts obtained were due to this fault in the handling of the samples. However, since the chief purpose of this table is to compare the cell content of hand-drawn and machine-drawn milk, and inasmuch as this error of technique is not correlated in any way with this comparison, the counts made from these smears have been included.

All of the counting of the smears reported upon in Table II after Count No. 1 was done by Mr. First.

Table III gives the average cell count of the milk of each of the cows in the herd together with the grand average for the herd. Eighteen of the 25 cows gave average cell counts of less than 500,000 cells per cubic centimeter, six gave counts averaging between 500,000 and 1,000,000 cells per cubic centimeter and one gave a cell count higher than 1,000,000 per cubic centimeter. The seven cows giving cell counts higher than 500,000 per cubic centimeter were Gerty F. 1, Hammond 2, Mabel S. F., Millie D., Millie G., Millie F., and Nora D. This list includes one cow which had suffered from udder troubles (Millie G.), two cows which had aborted recently (Mabel S. F. and Millie F.), and two old cows (Millie D. aged ten and Hammond 2 aged twelve). So far as the records show, Gerty F. 1 possessed no characteristic which has ever been thought to have an influence in producing high counts.

TABLE II.— NUMBER OF CELLS PRESENT PER CUBIC CENTIMETER OF MILK FROM COWS OF STATION HERD.

Counts are given in thousands per cubic centimeter. **Bold face type indicates hand-drawn samples**; all others machine-drawn samples.

No.	Name of Cow.	Age	Month of lactation, Feb. 1, 1911.	Count No. 1, February 10,13 or 14.		Count No. 2, February 26, 27.		Count No. 3, March 22, 23.		Count No. 4, May 7, 8.		Count No. 5, June 1, 2.		Count No. 6, June 25, 26.		Count No. 7, July 26, 27.		Count No. 8, August 30, 31.		Date of calving.
				Number cells.	Milk.	Number cells.	Milk.	Number cells.	Milk.	Number cells.	Milk.	Number cells.	Milk.	Number cells.	Milk.	Number cells.	Milk.	Number cells.	Milk.	
		Yrs.			Lbs.		Lbs.		Lbs.		Lbs.		Lbs.		Lbs.		Lbs.		Lbs.	
1	Anna G.	7	5	**65**	10.5	**90**	10.8	85	10.0	**10**	10.1	**865**	9.8	**5**	7.3	15	10.8	Dry.	....	Nov. 11
2	Carey of the Station	8	8	**75**	7.1	80	6.9	**145**	6.7	**940**	6.3	**1,050**	5.3	**50**	5.6	770	9.6	765	7.2	July 7
3	Carey of S. B. B.	3	4	65	7.8	135	8.2	105	7.5	735	8.6	5	8.7	10	8.8	355	7.1	60	5.5	
4	Carey S. F.	4	2	10	13.3	45	10.8	70	11.7	1,025	11.7	15	10.2	680	8.6	30	7.7	15	7.8	
5	Carey Fairy	5	6	**90**	9.2	**165**	9.7	**115**	8.6	**170**	10.1	**620**	7.5	**170**	5.3	Dry.	....	*	....	Aug. 29
6	Carey F. B. B.	3	3	240	9.2	430	6.2	195	6.8	1,005	6.5	1,475	6.3	20	6.5	460	5.5	5	5.6	
7	Chloe B.	5	0	Dry.	....	Dry.	....	235	14.9	30	12.9	450	10.6	460	10.6	0	9.3	30	8.0	Mar. 3
8	Dolly F. B. B.	3	7	125	8.3	240	8.5	520	7.6	325	6.7	430	6.3	5	3.1	Dry.	....	**35**	12.2	Aug. 1
9	Dotshome Carey	11	7	**65**	10.5	**190**	10.7	**415**	7.9	**105**	6.9	**440**	5.2	**515**	5.1	165	14.5	35	10.3	July 6
10	Gerty F. 1	6	7	295	6.0	485	5.2	1,020	4.2	890	3.9	390	4.0	505	4.1	Dry.	....	**1,170**	14.4	Aug. 14
11	Gerty F. 1. B. B.	3	3	20	8.8	425	9.0	50	8.6	5	8.6	5	7.7	115	8.4	70	6.3	5	4.8	
12	Gerty F. 2	5	6	130	4.0	425	6.0	235	5.8	350	4.0	380	4.0	450	4.0	Dry.	....	**20**	13.3	Aug. 27
13	Gerty F. 3	4	7	**110**	9.3	**375**	8.5	**390**	9.1	**340**	9.4	**120**	8.5	**5**	9.8	Dry.	....	†	12.4	Aug. 4
14	Hammond 2	12	5	**35**	14.0	265	14.6	**190**	14.2	**995**	14.8	**1,435**	14.4	775	11.1	**820**	11.0	**2,160**	13.5	
15	Hammond F. 1	5	5	420	7.3	400	6.8	410	7.1	595	6.6	860	5.2	350	3.8	Dry.	....	Dry.	....	
16	Hammond F. 2	4	2	**20**	14.0	**90**	16.7	75	15.0	**15**	15.5	**305**	13.3	220	12.6	555	9.8	**70**	7.8	
17	Mabel S. F.	6	3	1,200	5.2	805	4.1	820	3.0	90	2.8	‡	....	Dry.	....	Dry.	....	Dry.	....	
18	Millie D. of the Station	10	8	1,360	4.8	1,365	4.3	1,500	4.0	Dry.	3.2	Dry.	....	Dry.	....	Dry.	....	Dry.	....	
19	Millie of Geneva	9	5	**515**	8.3	565	9.1	**925**	8.3	**830**	8.1	†	7.2	**790**	4.3	**905**	7.6	Dry.	....	Sept. 6
20	Millie F.	7	2	1,990	7.5	745	6.4	785	5.2	400	4.2	650	2.6	Dry.	....	Dry.	....	Dry.	....	Dec. 3
21	Millie F. B. B.	5	1	10	12.8	85	13.8	50	10.7	10	11.3	1,170	8.6	545	9.5	575	6.9	10	6.4	
22	Nora D.	8	1	350	16.2	385	18.5	425	16.9	1,275	16.6	5	14.2	160	13.1	780	11.1	1,360	9.0	
23	Nora F. B. B.	3	1	45	13.5	280	11.9	200	9.3	1,005	6.7	600	5.3	10	5.3	240	5.8	5	1.5	
24	Ruth F.	5	8	160	5.0	470	5.2	450	4.0	Dry.	....	Dry.	....	Dry.	....	215	18.2	20	16.5	June 26
25	Ruth F. B. B.	2	0	Dry.	....	Dry.	....	65	9.6	10	10.2	820	10.3	260	10.3	15	8.6	135	8.2	Mar. 12

* Sample not taken. † Slide lost. ‡ Nearly dry.

TABLE III — AVERAGE CELL CONTENT OF THE MILK OF THE COWS OF THE STATION HERD.

No.	NAME OF COW.	Number of tests in average.	Cells per cubic centimeter.
1	Anna G	7	162,000
2	Carey of the Station	8	484,000
3	Carey of S. B. B	8	184,000
4	Carey of S. F	8	236,000
5	Carey Fairy	6	222,000
6	Carey F. B. B	8	479,000
7	Chloe B	6	201,000
8	Dolly F. B. B	7	240,000
9	Dotshome Carey	8	241,000
10	Gerty F. 1	65	516,000
11	Gerty F. 1 B. B	8	86,000
12	Gerty F. 2	7	284,000
13	Gerty F. 3	6	223,000
14	Hammond 2	8	834,000
15	Hammond F. 1	64	277,000
16	Hammond F. 2	8	169,000
17	Mabel S. F	62	706,000
18	Millie D. of the Station	3	1,408,000
19	Millie of Geneva	68	941,000
20	Millie F	5	914,000
21	Millie F. B. B	8	307,000
22	Nora D	8	592,000
23	Nora F. B. B	8	298,000
24	Ruth F	5	263,000
25	Ruth F. B. B	6	217,000
	Grand average	....	439,000

The above evidence, if it stood alone, might be regarded as indicating the truth of the statements which have been made concerning the influence of the various factors mentioned. But when the group of cows which gave low cell counts is examined, it is seen that this includes one cow which had had udder troubles recently and still had a hard lump in her udder (Chloe B.), one cow which had aborted recently (Ruth F. B. B.), and one cow eleven years old (Dotshome Carey). Moreover all but two cows in the herd gave individual tests higher than 500,000 cells per cubic centimeter, and it is probable that these two animals would have given higher counts also if more tests of their milk had been made. Thirteen of the 25 cows gave individual tests higher than 1,000,000 cells per cubic centimeter. This makes it highly probable that

all cows give high cell counts, i. e. higher than a half million or more cells per cubic centimeter, at some time during their lactation period.

The grand average for the Station herd is only 439,000 cells per cubic centimeter, a number much lower than that found in the case of the other herds examined (See page 142).

B. CELL CONTENT OF THE MILK OF A HERD OF GUERNSEY CATTLE.

Table IV gives a record of the cell counts which were made on March 2, 1911, of a herd of registered Guernseys owned by Mr. A. G. Lewis of Geneva. All of these animals were tuberculin-tested and free from tuberculosis and many of them were imported animals, some having been imported within six months. The stabling and care of the animals were excellent. The samples were taken and the smears made by the author, but the cell counts were made by Mr. Stidger.

The grand average for the cells counts of these fifty-three animals is 895,000 cells per cubic centimeter. Twenty-seven animals gave counts of less than 500,000 cells per cubic centimeter, sixteen animals gave counts between 500,000 and 1,000,000 cells per cubic centimeter, while ten gave counts above 1,000,000 cells per cubic centimeter. There is nothing peculiar in the record of the animals which give the high counts so far as can be seen from the data which were secured concerning them.

TABLE IV.— CELL CONTENT OF THE MILK OF 53 GUERNSEY COWS. TEST MADE MARCH 2, 1911.

No	NAME OF COW.	Number of cells per cubic centimeter.	Age, years.	Pounds of milk.	Pounds milk in Feb.
7	Pioneers Busy Bee	6,950,000	8	?	?
37	Raymonds Maid	1,915,000	4	1.3	158
92	Blanchflower of Lewisson	165,000	4	10.2	665
234	Lily of les Effards	1,330,000	4	8.2	662
240	Blossom II of the Ponchez	500,000	4	4.7	399
242	Bessie of Mt. Plaisant VI	3,440,000	4	8.6	614
253	Flora of the Preel II	235,000	4	2.1	239
285	Rosie of Baisseres Place	265,000	4	2.3	288
288	Raymond's Primrose	390,000	4	9.6	698
292	Bijou VII of Beaulieu	370,000	4	14.8	?

Table IV.—Cell Content of the Milk of 53 Guernsey Cows. Test Made March 2, 1911—(*Concluded*).

No.	Name of Cow.	Number of cells per cubic centimer.	Age, years.	Pounds of milk.	Pounds milk in Feb.
307	Doris III of the Tertre	130,000	5	?	?
313	Lady of the Lewisson	240,000	4	11.0	754
328	France XVIII	395,000	6	12.4	690
329	France XIII	3,810,000	7	6.5	341
407	Grany V of the Choppius	815,000	6	7.4	374
408	Nellie IV of the Baisseres	690,000	4	?	?
414	France XXIII	65,000	5	9.5	611
421	Dolly of the Hougnette	130,000	4	3.1	258
422	Torteval of Vinicra	470,000	4	7.8	403
423	Muzette XI	550,000	4	6.0	477
429	France XVIII's Daughter	145,000	3	12.2	856
489	Ouida of the Isle	345,000	2	?	?
507	Sylph's Pride IV	640,000	4	9.6	667
510	Raymond's Desire	895,000	4	5.0	386
511	Raymond's Daisy of Mt. Plaisant	410,000	4	7.5	526
514	Raymond's Stella	555,000	4	10.7	787
520	Raymond's Poundstock	560,000	4	13.5	?
523	Rose of the Frequet	205,000	2	10.7	647
604	Raymond's Miss Freda	135,000	4	9.0	667
608	Sequel's Bounty	1,210,000	4	6.1	457
609	Fine Star	250,000	4	9.3	581
610	Snow White Queen	95,000	5	7.7	539
616	Jenemies Daisy II	3,860,000	2	9.6	?
682	Polly II of the Cloture	160,000	3	5.9	367
723	Bilinda III	725,000	4	5.4	392
726	Beauty of Ida Cottage	705,000	4	6.2	402
727	Bissette XLVII	615,000	4	8.7	524
729	Buttercup of the Poidevins	815,000	8	?	?
731	Raymond's Bijou VI of Beaulieu	975,000	4	4.1	283
733	Miriam III of the Isle	1,370,000	7	?	331
755	Maggie of Foulon	840,000	3	8.2	497
781	Lady of Messuriers	1,190,000	8	9.1	630
786	Trewiddem Pansy	850,000	3	10.5	579
788	Lady Lihon III	445,000	3	5.9	358
791	Bilinda IV	405,000	3	11.8	736
800	Raymond's Lady Poundstock	165,000	5	8.9	680
801	Lady Gree III	165,000	7	?	?
802	Primrose of the Gree III	305,000	8	8.2	497
803	Toulouse Maid VI	3,870,000	8	9.2	615
804	Polly of the Russell	135,000	8	5.1	?
806	July Rose of the Hall	705,000	3	6.7	392
807	Primrose of the Gree IV	430,000	5	4.1	273
808	Mignonne of the Hall	305,000	2	......	....
	Grand average for 53 cows	895,000			

TABLE V.—BACTERIA PRESENT IN THE UDDERS OF 43 OF

No. of cow.	Days in milk.	Number of Bacteria per Cubic Centimeter of Strippings.					
		Right front quarter.			Right hind quarter.		
		First count.*	Second count.*	Notes.†	First count.*	Second count.*	Notes.†
7	35	26	27	All—M. 211.2323032 ...	1,123	1,123	Culture lost..........
37	245	0	673	All—M. 211.2223033....	1	7	....
240	273	1	2	....	2	7	....
242	46	2	5	3—M. 211.2323033.....	0	16,610	All—Str. 222.2223033 .
253	49	10	11	....	1	10	....
285	321	0	1	....	0	132	All—M. 212.2223033 ..
292	9	1	61	59—Yeast............	0	1	....
307	9	1	1	....	2	16	....
328	82	2	9	....	0	8	....
329	393	0	1	....	3,600	3,600	All—Str. 211.2223033 .
407	233	3	3	....	0	350	All—M. 212 2223033 ..
408	35	5	10	....	0	7	....
414	119	6	47	20—M. 212.2223033....	3	4	....
421	284	0	0	....	0	0	....
429	66	20	31	....	31	45	....
489	6	56	184	....	47	54	....
507	138	0	2	....	0	2,230	All—M. 212.2222033 ..
510	38	0	3,180	All—M. 211.2233033 ...	4	13	3—M. 212.3333533....
511	184	3	25	23—M. 212.2223533....	7	7	....
523	64	1	5	....	2	2	....
608	288	1	37	36—M. 211 2233033....	2	28	....
609	77	78	180	....	120	160	80—M. 211.2223033... 50—M. 211.2223533... 1—M. 212.2222033...
610	121	1	4	....	1	1	....
616	19	8	45	30—M. 212.2223533....	40	340	200—M.211.2323033...
682	229	1	1	....	3	4	....
723	273	15	15	....	4	17	....
726	181	2	39	....	4	12	....
727	109	0	5	....	0	3	....
729	367	5	38	....	2,380	2,380	....
733	192	0	0	....	0	3	All—M. 212.2232533 ..
755	130	4	7	....	1	1	....
781	79	34	44	24—Bact. 211.3332513...	2	2	....
786	31	0	63	All—M. 221.2223532 ...	0	2	....
788	117	4	13	....	3	34	31—Bact. 212.2332033.. 3—M. 212 2223532....
791	77	10	20	....	1	4	....
800	73	1	2	1—M. 211.2223033..... 1—M. 211.2223633.....	1	2	....
801	21	2	3	....	2	11	....

the 53 Cows Whose Cell Counts are Given in Table IV.

Number of Bacteria per Cubic Centimeter of Strippings.						
Left front quarter.			Left hind quarter.			
First count.*	Second count.*	Notes.†	First count.*	Second count.*	Notes.†	No. of cow.
2	3	....	3	46	All—M. 212.2222533	7
0	4	....	0	55	....	37
2	4	1—M. 211.2323033........	2	220	All—M. 212.3332033	240
		1—Yeast...............				
40	45	All—M. 212 3333033	2	5,280	5278—M. 211.2223533....	242
2	16	....	0	5	All—Bact. 212.3332033 ...	253
0	14	All—Bact. 212 3332033 ...	0	26	....	285
2	250	248—Bact. 212.3332033....	1	2	....	292
1	2	....	0	1	....	307
1	2	....	0	0	....	328
0	1,340	All—Str. 211.2223033	1	2	....	329
1	5	....	0	1,220	....	407
10	24	14—M. 211.2323033.......	14	34	14—M. 212.3332033......	408
					1—Bact. 211.3332513....	
5	29	....	11	125	114—M. 211.2233033.....	414
1	1	....	0	80	All—M. 211.2233033	421
40	68	....	18	44	....	429
108	108	....	143	175	28—M. 211.2323033.....	489
					147—M. 211.2223033.....	
....	.....	Three-teated cow.........	1	1	....	507
5	316	....	9	2,110	....	510
0	1	....	0	4	....	511
5	7	....	6	16	....	523
4	34	4—M. 212.3333633........	2	14	....	608
9	113	....	21	64	....	609
1	3	....	2	3	....	610
208	510	400—M. 211.2323033......	10	17	....	616
2	4	....	8	8	....	682
34	34	All—M. 211.2323932	230	490	All—Bact. 222.2222032 ...	723
1	7	....	0	9	....	726
1	6	All—M. 222.2223533	4	10	....	727
0	1,300	....	714	714	....	729
18	78	25—M. 212.2223033.......	1	350	348—Bact. 212.2223023...	733
		30—M. 212.3333533.......			1—Yeast..............	
27	67	....	14	38	....	755
1	9	....	?	3,440	All—M. 211.2223633	781
3	30	....	0	0	....	786
3	89	39—Bact. 212.2332633.....	2	30	....	788
5	5	....	15	25	15—Yeast 212.2332013....	791
8	53	1—M. 212.2333533.......	2	7	....	800
		21—M. 211.2323033.......				
		8—M. 212.3333033.......				
3	3	....	0	0	....	801

TABLE V.— BACTERIA PRESENT IN THE UDDERS OF 43 OF

No. of cow.	Days in milk.	NUMBER OF BACTERIA PER CUBIC CENTIMETER OF STRIPPINGS.					
		RIGHT FRONT QUARTER.			RIGHT HIND QUARTER.		
		First count.*	Second count.*	Notes.†	First count.*	Second count.*	Notes.†
802	200±	27	58	....	0	2	....
803	200±	0	0	....	6	6	....
804	?	0	430	All—M. 211.2233533 ...	0	1	....
806	200±	3	5	....	1	8	....
807	200±	17	27	....	3	5	....
808	32	23	45	....	12	46	....

* The agar plates were first incubated for five days at 20–23 degrees C. and colonies counted; then again incubated for two days at 37 degrees C. for second count.

† The first number given under "Notes" shows how many colonies on the agar plates had the same general appearance as the colony from which a culture was isolated. The group number following was determined in each case from this single isolated colony.

At the same milking that furnished the samples for study of the cell content, samples of strippings were collected in sterile test tubes, from each quarter of the udder of forty-three of these cows by Mr. Wilson and Mr. Ruehle. With the help of Dr. Harding, these samples were plated in duplicate in lactose agar using one-half cubic centimeter of undiluted milk for each plate. Mr. Wilson studied the udder flora as follows: The plates were incubated for five days at 20–23 degrees C. and counted; then again incubated at 37 degrees C. for two days and recounted. Sixty-one cultures were isolated and studied as described in Technical Bulletin No. 27. The results of the tests made to determine the group numbers of these cultures are given in Tables IX and XII of the bulletin referred to. The details of the counts obtained and the cultures isolated from each quarter are given in Table V of the present bulletin.

Since the meaning of the group number as here used is not familiar to everyone, the tabular statement opposite, taken from the standard card recommended by the Society of American Bacteriologists, is given:

THE 53 COWS WHOSE CELL COUNTS ARE GIVEN IN TABLE IV — *Continued.*

NUMBER OF BACTERIA PER CUBIC CENTIMETER OF STRIPPINGS.						
LEFT FRONT QUARTER.			LEFT HIND QUARTER.			No. of cow.
First count.*	Second count.*	Notes.†	First count.*	Second count.*	Notes.†	
2	13	11—M. 221.2222632.......	9	9	....	802
16	20	....	5	7	....	803
0	3	....	4	9	....	804
3	38	35—Bact. 212.3333033.....	97	740	370—M. 211.2223033..... 370—M. 212.2222532.....	806
3	5	....	15	31	....	807
4	12	....	4	23	15—M. 222.2223533......	808

A NUMERICAL SYSTEM OF RECORDING THE SALIENT CHARACTERS OF AN ORGANISM. (GROUP NUMBER)

100.	Endospores produced
200.	Endospores not produced
10.	Aerobic (Strict)
20.	Facultative anaerobic
30.	Anaerobic (Strict)
1.	Gelatin liquefied
2.	Gelatin not liquefied
0.1	Acid and gas from dextrose
0.2	Acid without gas from dextrose
0.3	No acid from dextrose
0.4	No growth with dextrose
.01	Acid and gas from lactose
.02	Acid without gas from lactose
.03	No acid from lactose
.04	No growth with lactose
.001	Acid and gas from saccharose
.002	Acid without gas from saccharose
.003	No acid from saccharose
.004	No growth with saccharose
.0001	Nitrates reduced with evolution of gas
.0002	Nitrates not reduced
.0003	Nitrates reduced without gas formation
.00001	Fluorescent
.00002	Violet chromogens
.00003	Blue "
.00004	Green "
.00005	Yellow "
.00006	Orange "
.00007	Red "
.00008	Brown "
.00009	Pink "
.00000	Non-chromogenic
.000001	Diastasic action on potato starch, strong
.000002	Diastasic action on potato starch, feeble
.000003	Diastasic action on potato starch, absent
.0000001	Acid and gas from glycerine
.0000002	Acid without gas from glycerine
.0000003	No acid from glycerine
.0000004	No growth with glycerine

The genus according to the system of Migula is given its proper symbol which precedes the number thus:

BACILLUS COLI (Esch.) Mig.	becomes	B.	222.111102
BACILLUS ALCALIGENES Petr.	"	B.	212.333102
PSEUDOMONAS CAMPESTRIS (Pam.) Sm.	"	Ps.	211.333251
BACTERIUM SUICIDA Mig.	"	Bact.	222.232203

A comparative study of the results obtained from the bacterial and the cell counts is very interesting. Some of the facts which have been noted are as follows:

a. In the case of nine cows whose udder flora was studied and whose cell count was higher than 1,000,000 cells per cubic centimeter, six showed a bacterial count higher than 500 per cubic centimeter in one or more quarters (i. e. Cows Nos. 7, 37, 242, 329, 616, 781).

b. Of the eleven cows which showed 500 or more bacteria per cubic centimeter in one or more quarters of their udder (i. e. Cows Nos. 7, 37, 242, 329, 407, 507, 510, 616, 729, 781, 806), the lowest cell count was 640,000 cells per cubic centimeter (Cow No. 507, a three-teated cow). Five of these cell counts were lower than 1,000,000 and six were higher than 1,000,000.

c. However, three cows with high cell counts showed low bacterial counts; i. e., Cow 608 with a cell count of 1,210,000 and bacterial counts of 37, 28, 34 and 14 respectively in each quarter, Cow 733 with a cell count of 1,370,000 and bacterial counts of 0, 3, 78 and 350 respectively, and Cow 803 with a cell count of 3,870,000 and bacterial counts of 0, 6, 20 and 7 respectively. The last cow had next to the highest cell count of any animal in the herd.

d. In the nine cows with cell counts under 200,000 per cubic centimeter whose udder flora was determined (Cows Nos. 307, 414, 421, 429, 610, 682, 800, 801 and 804), twenty-six out of the thirty-six quarters gave bacterial counts under ten bacteria per cubic centimeter, and only two quarters showed bacterial counts higher than eighty per cubic centimeter, i. e., 125 in the left hind quarter of Cow 414, and 430 in the right front of Cow 804. The total count for all four quarters was less than 450 in every one of the nine cows.

It is clear from the above data that a high cell count is not always caused by a rich bacterial infection of the udder. There is, however, some indication that a rich bacterial infection causes a high cell count, but the records are inconclusive. Further records bearing on this point are given on pages 150–3.

The interpretation of the data from the qualitative standpoint is almost impossible because of the confusion which exists in the classification of the Coccaceae, to which a majority of the udder bacteria belong. It should be noted that the udders of almost all of the cows were infected with micrococci very similar to

micrococci found generally on the skin of man and animals. Many bacteriologists believe these to be indistinguishable from the pus-forming cocci generally spoken of as *Micrococcus* (*Staphylococcus*) *pyogenes*.

The two strains of streptococci isolated from udders as given by Harding and Wilson in Technical Bulletin No. 27 were both isolated from this herd at this time. One of these with the group number Str. 222.2223033 appeared as an apparently pure culture in the right hind quarter of Cow 242. This quarter gave a bacterial count of 16,610 per cubic centimeter which was the highest obtained from any quarter of any cow in the herd. The left hind quarter of the same cow gave a bacterial count of 5280 per cubic centimeter but this was due to an apparently pure culture of a yellow chromogenic micrococcus which, when isolated, gave the group number M. 211.2223533. The interesting fact to note was that the cell count of this cow was high, namely 3,440,000 per cubic centimeter.

The second streptococcus, which had the group number Str. 211.2223033, was apparently present in pure culture in both the right hind and the left front quarters of Cow 329. The bacterial counts for these two quarters were 3600 and 1340 per cubic centimeter respectively. The cell count for this cow was likewise high, namely, 3,810,000 per cubic centimeter.

The characteristics of the colonies which grew on the plates inoculated with milk from the right hind quarter of Cow 7 (bacterial count of 1123) were such that there is good reason for thinking that the form present in this case was a streptococcus. The culture isolated was lost because of failure to grow well on ordinary media, a further characteristic of the streptococci. The cell count for this cow was 6,950,000 per cubic centimeter which was the highest found for any cow in this herd.

The fact that the three cows known or suspected to have had a streptococcic infection of the udder gave three of the highest cell counts in the herd is suggestive especially when combined with what other investigators have reported. Nevertheless the fact that there were two other cows (Nos. 616, 803) which gave equally high counts while there is little or no reason for suspecting that a streptococcic infection existed compels caution in the interpretation of this result. More data of this sort must be secured before the real condition of affairs will become evident.

There was one three-teated cow in the herd (No. 507) which had presumably lost her quarter (left front) because of some bacterial infection. This cow gave a cell count of 640,000 per cubic centimeter and bacterial counts of 2 for the right front quarter, 2230 for the right hind quarter, and 1 for the left hind quarter. The cell count is the lowest given for any cow having a bacterial infection in any quarter greater than 500 per cubic centimeter, a number which is likewise smaller than the average for the herd. The bacteria present in the case of the right hind quarter apparently belonged to a single species which gave the group number M. 212.2222033. The culture produced small pin point colonies on agar similar in all respects to the colonies produced under like circumstances by the streptococcus isolated from Cow 242 but no tendency to chain formation was noted so that it was classified as a micrococcus.

C. AVERAGE CELL CONTENT OF THE MILK OF NORMAL COWS.

Table VI has been drawn up in order to summarize all our known data giving the cell content of the milk of individual cows. All of the 122 cows referred to were supposed by their owners to be giving normal milk, although the list includes several animals that had had udder troubles of one kind or another at earlier periods in their

TABLE VI.—SUMMARY OF DATA SHOWING CELL CONTENT OF NORMAL MILK

Number of cows in herd.	Herd from	Average number of cells per cubic centimeter.	Number of cows giving cell counts between			Breed of cow.
			0–500,000.	500,000–1,000,000.	1,000,000 and up.	
41	*Meadville, Pennsylvania.	1,089,000	13	13	15	Jersey and mixed grades.
3	*Germany.......	932,000	1	1	1	Harz and Glaner.
25	Exper Station, Geneva.	439,000	18	6	1	Jersey and Grade Jersey.
53	Geneva, N. Y...	895,000	27	16	10	Guernsey.
Total.....................		....	59	36	27	
Grand av. for 122 cows...		868,000				

* Quoted from Breed and Stidger. See footnote 1.

history. Nearly all of the animals had been tuberculin tested, though the list is thought to include a few animals from the Meadville herd which reacted to the tuberculin test soon after these tests were made. The total number of these reacting animals could not have been more than six.

It will be seen that there is considerable difference between the various herds so far as the cell content of their milk is concerned. The Station herd gives an average cell count of less than half the cell count of any of the other herds. The most noticeable difference in the management of these herds which might have caused this difference was that the animals in the Station herd had been milked by machine during alternate lactation periods for four years previous to the time when this test was made while the other herds had all been milked by hand. The possibility that this difference in the method of milking may have had an influence is supported by the evidence given on pages 173–175.

Of the 122 cows, 59 gave cell counts under 500,000 cells per cubic centimeter, 36 gave cell counts between 500,000 and 1,000,000 per cubic centimeter, while 27 gave cell counts higher than 1,000,000 per cubic centimeter. There is no evident difference between the three groups of animals. Of the three cows which are known to have suffered from udder troubles previous to the time of the test, one gave a cell count under 500,000 and the other two gave cell counts between 500,000 and 1,000,000. The general average for the 122 cows was 868,000 cells per cubic centimeter. More than half of the cows had cell counts higher than 500,000 per cubic centimeter.

D. CELL CONTENT OF GOAT-MILK.

During the course of present investigations, an examination was made of the milk of nine of the goats kept at the Experiment Station. The results of the examinations are given in Table VII. For comparison, the figures given by Breed and Stidger for two goats from Göttingen, Germany, have also been included. The numbers of cells found were uniformly high and in one case in particular (No. 8) the milk was filled with enormous numbers of cell fragments which made it impossible to determine the number of cells accurately. The figure given represents merely an approximation. The average cell content of the milk of the 11 goats was 7,465,000 per cubic

centimeter, a figure which is much higher than that given for cow-milk. The cell counts were made by Mr. Stidger.

TABLE VII.— CELL CONTENT OF GOAT-MILK.

No. goat.	Cells per cubic centimeter.	Age.	Days in milk.	Milk.*	Milk.†	Breed of goat.
				Lbs.	*Lbs.*	
1	1,410,000	4	21	2.9	7.5	Schwarzwald
2	1,870,000	4	27	2.6	7.1	Toggenburg
3	2,840,000	8	20	2.0	5.9	Toggenburg
4	1,125,000	5	337	2.8	‡2.8	Toggenburg
5	30,250,000	5	24	2.1	6.7	Toggenburg
6	17,050,000	2	29	2.3	6.4	Toggenburg
7	2,775,000	4	28	3.6	10.8	Saanen
8	14,450,000	6	31	1.2	3.9	Guggesburg
9	8,675,000	5	19	2.0	4.5	Saanen
§10	425,000	3	215	?	?	?
§11	2,245,000	5	215	?	?	?
Ave.	7,465,000					

* Pounds of milk given at the milking from which test was made.
† Pounds milk given in 24 hours.
‡ Milked once a day.
§ Quoted from Breed and Stidger (p. 381). See footnote 1.

II. CELL CONTENT OF MILK IN RELATION TO THE PERIOD OF LACTATION.

The only satisfactory kind of data to show the relationship which may exist between the period of lactation and the number of cells discharged during different portions of the lactation period would be daily records of the number and kinds of cells discharged during the complete lactation periods of a sufficiently large number of normal animals to eliminate chance variations. Unfortunately the present investigations have been carried out under such circumstances that it has been impossible to keep such records.

During the investigations the milk of several animals has been examined daily for several weeks or for longer periods at occasional intervals. These show some of the conditions which prevail and so are given in the following pages.

A. CELL CONTENT OF THE MILK OF FRESH COWS.

The milk of two fresh cows was studied, both of whom were more or less abnormal and might therefore be expected to give high cell

counts. No cells of a type different from those found in later stages of lactation were found in the colostral milk.

Chloe B. (No. 7).— The first cow studied was Chloe B. She was a grade Jersey, five years old and had always calved normally. At the end of the lactation period just previous to the one studied, she developed an abscess between the forward quarters of her udder which healed and formed a bunch between these quarters several inches long. This was gradually absorbed but was still two or three inches in diameter at the time she calved in March, 1911. Her calf was born during the night of March 2, was a normal calf, and soon began to take his share of the milk. Samples of mixed milk were taken from the pail at each milking, but inasmuch as the calf took part of the milk until the evening of March 7, the samples taken before this date do not represent a sample of the entire milking. Samples of milk were taken from single streams of each quarter of the udder beginning with the evening of March 4. As shown in Table VIII, these samples were taken either from the first stream drawn, or when the milking was approximately half done, or from the strippings. Samples of the foremilk, middlemilk and strippings were taken from the evening milkings only.

Table VIII.— Cell Content of the Milk of Chloe B. (No. 7).
Numbers given in thousands per cubic centimeter.

Date, 1911.	Number of cells in whole milk.	Number of cells in the milk of each quarter.				Milk	Notes.
		Right front.	Right hind.	Left front.	Left hind.		
Mar. 1	4,300						Sample drawn thirty hours before calving. Milk thin and watery. Blood in left hind quarter.
3	7,940 5,400					*Lbs.* 7.5+	Hand milked. Milk decidedly bloody.
4	6,970 2,080	M.* 4,405	4,150	1,550	2,825	7.3+ 3.0+	Milk from R. F. quarter very bloody with trace of blood in R. H. quarter.
5	415 755	M. 570	385	290	470	7.8+ 4.5+	

*In the third column, the letter F=foremilk, M=middle milk, and S=strippings.

TABLE VIII.—CELL CONTENT OF THE MILK OF CHLOE B. (No. 7)—(*Continued*)
Numbers given in thousands per cubic centimeter.

Date, 1911.	Number of cells in whole milk.	Number of cells in the milk of each quarter.					Milk.	Notes.
			Right front.	Right hind.	Left front.	Left hind.		
Mar.							*Lbs.*	
6	295						6.8+	Still trace of blood in R. F.
	230	M.*	130	50	30	230	1.8+	quarter.
7	95						7.5+	Calf sold.
	140	M.	105	105	50	515	11.1	No blood to be seen.
8	140						14.2	
	90	M.	30	25	10	225	11.4	
9	35						14.5	Milk entirely normal in
	40						10.8	appearance
10	2,755						14.1	
	4,050	F	10	10	40	15,135		
		M	30	30	25	15,080	12.7	
		S	35	55	70	54,300		
11	.....						15.2	
	690	M	10	20	375	1,305	14.2	
		S	45	35	1,300	18,215		
12	425						15.8	
	395	M	25	20	345	1,080	12.8	
		S	50	25	515	4,060		
13	275						16.4	
	880	M	30	10	3,060	260	13.4	
		S	70	35	4,420	1,920		
14	1,530						16.2	
	4,350	M	10	10	1,170	9,640	13.2	
		S	150	70	5,160	42,000		
15	1,100						15.3	
	1,225	M	5	10	1,060	2,600	14.4	
		S	20	25	2,830	8,000		
16	660						15.8	
	495	M	15	10	800	1,020	13.1	
		S	45	25	3,900	2,520		
17	155							
	375	M	20	15	770	140	15.2	
		S	25	25	3,495	1,650	14.5	

*In the third column, the letter F=foremilk, M=middle milk, and S=strippings.

Table VIII.— Cell Content of the Milk of Chloe B. (No. 7) — (*Concluded*).
Numbers given in thousands per cubic centimeter.

Date, 1911.	Number of cells in whole milk.	Number of cells in the milk of each quarter. Right front.	Right hind.	Left front.	Left hind.	Milk.	Notes.
Mar.						*Lbs.*	
18	760						
	1,050	M* 20	50	610	3,320	15.7	
		S 110	60	2,940	12,690	14.6	
19	320						
	480	M 20	5	930	450	15.3	
		S 70	10	1,860	2,880	14.3	
20	275					15.0	Began milking with machine at evening milking
	115					15.6	
21	110					15.1	
	170					12.5	
22	440					15.1	
	225					13.8	
23	215					16.0	
	200					15.4	
24	330					14.8	
	245					14.6	

*In the third column, the letter F = foremilk, M = middle milk, and S = strippings.

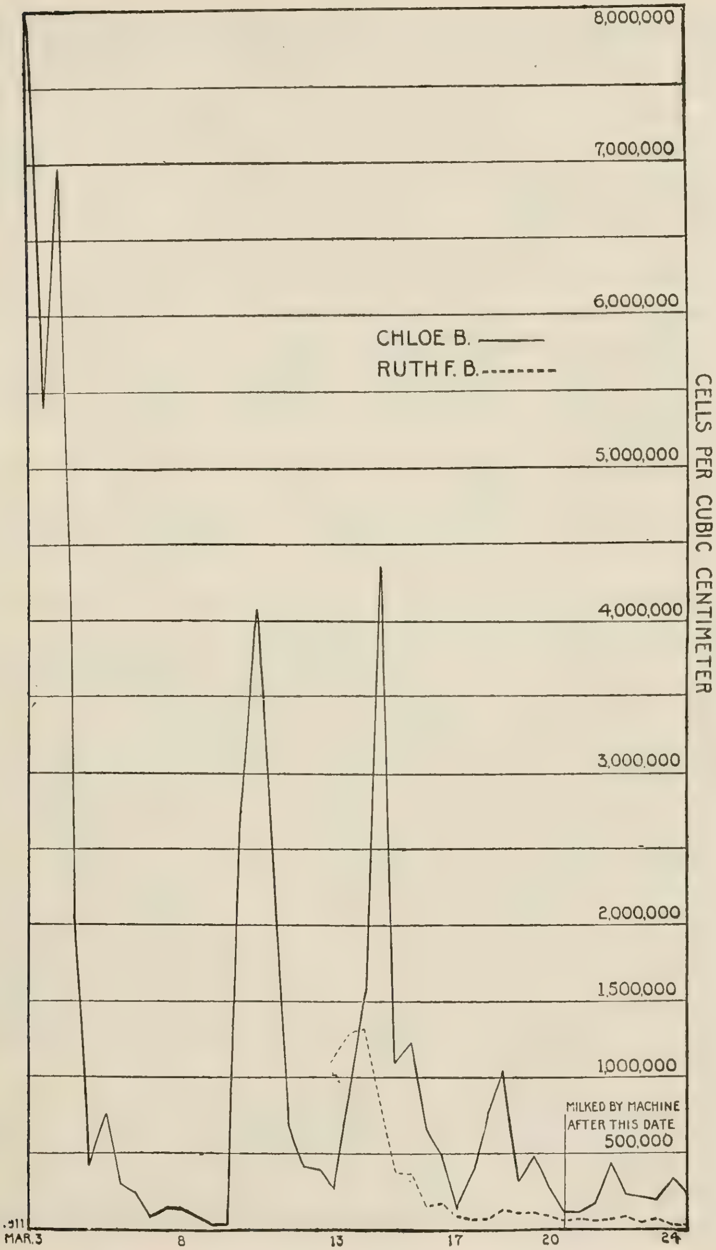
Some milk was drawn from each quarter of the udder on the evening of March 1 about thirty hours before calving. This colostral milk was thin and watery and contained more or less blood, especially from the left hind quarter. The milk drawn on March 3 and the morning of March 4 was decidedly bloody, that is to say, the whole quantity of milk had a deep pink color and a clot of blood formed on the top of the samples of milk in the test tubes after standing. On the evening of March 4, samples were drawn from each quarter separately, when it was found that it was the right front quarter which was giving the very bloody milk, while the milk from the right hind quarter showed blood also, but in small quantity.

The amount of blood in the milk from the right front quarter was less on the next morning (March 5) but again appeared in quantity at the evening milking. No blood showed in the milk from the other quarters at this milking. The milk from the right front quarter was still slightly bloody on March 6 but no blood was noticeable after this date. The udder was distended and inflamed for several days but was not noticeably indurated. In other words, the changes in the udder and milk were not especially unusual except in the fact that the right front quarter discharged rather more blood than normally occurs.

A study of the cell content of the milk of this animal as given in Graph I (continuous line) shows that the greatest number of cells occurred in the first milk drawn after calving and that there was a very rapid diminution in number the following seven days until the low figure of 35,000 cells per cubic centimeter was found. On the following day there was a sudden return to a maximum of 4,050,000 cells per cubic centimeter, a figure which approaches those of the first two days. This was followed by a falling off in numbers during the following three days with another return to a maximum of 4,350,000 cells per cubic centimeter on March 14. The cell counts were low through the remainder of the period during which Chloe B was under observation, and none of the counts obtained later from her as given in Table II (p. 132) are excessively high.

A study of the counts from the individual quarters explains the details of some of these fluctuations. The right front quarter which gave the bloody milk on March 4 to 6 shows higher counts than the other quarters on March 4 and 5 but not on March 6 and at no time are the cell counts as much higher as would have been expected from the appearance of the milk. The count of 130,000 cells per cubic centimeter for the right front quarter on the eve of March 6, when the milk from this quarter was still noticeably bloody, is a low count and shows at once the impossibility of detecting bloody milk when mixed with herd milk by means of the cell count alone. After the first few days the number of cells in the milk of this quarter was very low and continued low as long as the milk was tested.

In none of the smears prepared from bloody milk were the red blood cells counted as they do not show clearly when the smears are stained with methylene blue as was done in this case.



Graph I.—Cell Content of Milk of Two Fresh Cows.
Milked by hand until evening of March 20.

After the third day the left hind quarter discharged a greater number of cells than any of the other quarters. This was one of the quarters which was distant from the lump in the udder above mentioned. The count on March 10 is especially interesting, for the strippings of the left hind quarter on this date gave the highest cell count of any apparently normal milk thus far examined. When viewed under the microscope, the milk was found to be simply filled with cells. Yet the macroscopic appearance of the milk was such that three trained laboratory men failed to detect which was the cell-rich milk when a sample in a test tube was placed beside three similar samples containing small numbers of cells. The milk from this animal was used with that of the other cows. The taste of the milk was entirely normal and caused the person who used it no evil after-effects.

A bacteriological examination of the milk of this cow was made by Mr. Ruehle from March 11 to March 19. The principal purpose of this work was to discover whether a relation exists between the number of cells discharged and the total bacterial infection as indicated by the number of bacteria discharged, and to discover whether any streptococcic infection existed.

The technique used was the same as that used by Harding and Wilson in their studies on the udder flora (Technical Bulletin No. 27). Samples of strippings from each quarter were drawn into sterile test tubes at each milking, plated on lactose agar and incubated for 5 to 6 days at room temperature (23 to 25 degrees C.) and the colonies counted. The plates were then incubated for two days longer at 37 degrees C. and recounted. The averages of the numbers of bacteria per cubic centimeter for the sixteen tests when incubated at the lower temperature were as follows: right front, 4; right hind, 75; left front, 2; left hind, 11; average of the four quarters, 23. When the plates were incubated at 37 degrees C. for two days longer, the counts rose to the following averages: right front, 9; right hind, 191; left front, 340; left hind, 260; average of four quarters, 175.

The averages in all of these cases are low as compared to those found for the udder by other investigators, so that it is evident there was no excessive number of bacteria present. Table IX shows the details in regard to the cell and bacterial counts so far as they were made under comparable circumstances. This

Table IX.— Cell and Bacterial Counts of Chloe B. (No. 7).

Cell counts made from single streams of milk drawn about the middle of the milking. Bacterial counts from the strippings. Numbers given per cubic centimeter.

Date.	Right front quarter.		Right hind quarter.		Left front quarter.		Left hind quarter.	
	Cell count.	Bacterial count.	Cell count.	Bacterial count.	Cell count.	Bacterial count	Cell count.	Bacterial count
March								
11	10,000	19	20,000	119	375,000	624	1,305,000	266
12	25,000	2	20,000	9	345,000	68	1,080,000	21
13	30,000	12	10,000	230	3,060,000	404	260,000	150
14	10,000	24	10,000	1,795	1,170,000	679	9,640,000	746
15	5,000	5	10,000	190	1,060,000	532	2,600,000	76
16	15,000	1	10,000	10	800,000	87	1,020,000	13
17	20,000	19	15,000	348	770,000	75	140,000	227
18	20,000	21	50,000	93	610,000	70	3,320,000	138
Averages	17,000	13	18,000	349	1,024,000	317	2,421,000	205

table shows that there is no close relationship between the number of bacteria and the cell counts even where these are taken under the most favorable circumstances for detecting such a relationship. Of the two right quarters which discharged very few cells, one had a very low bacterial content but the other gave the highest average bacterial content of all four quarters. The highest bacterial count obtained was found in this quarter (right hind on March 14) at a time when the number of cells discharged was only 10,000 per cubic centimeter. The two left quarters which were discharging cells by the hundreds of thousands per cubic centimeter had average bacterial counts of 317 and 205. In this case the quarter with the lower count discharged more than twice as many cells as the quarter with the higher count.

No streptococci could be demonstrated by microscopic examination of the colonies which grew on the agar plates. The increase in count at 37 degrees C. in both of the left quarters was largely due to a single species of micrococcus which was by far the most abundant organism present. This organism was identified by Wilson as being one of the common udder micrococci and probably the same as the one which Harding and Wilson have

described with the group number M. 211.2233033 which would place it as *Micrococcus lactis albidus.*

After the samples of strippings had been used for plating, they were then placed in a 37 degrees C. incubator and allowed to stand for three days after which they were examined microscopically for streptococci. Only one sample from the right side curdled under this treatment while almost all of the 16 samples from the left quarters curdled. This curdling was probably due to the micrococcus mentioned above. No streptococci could be demonstrated by this technique, making it doubly certain that none were present.

Ruth F. B. B. (*No. 25*).— The case of Ruth F. B. B. was quite different from that of Chloe B. Ruth F. B. B. aborted her first calf during the night of March 12, 1911, when she was 23 months old. The udder did not fill with milk as rapidly as normal and was never distended and swollen as is frequently the case.

Table X gives the record of the examination of the milk of this animal for cell content. The dotted line in Graph I (p. 149) shows more clearly how rapidly the number of cells in the milk fell off after the first two days. It never returned to high figures during the twelve days during which she was under observation. The number of cells in the colostral milk is not excessively high in this case. Many tests of milk from animals in later stages of lactation have been made where the counts were higher than any of these.

A great number of fragments of cells were noticed in the milk of the first few days and the cell counts for those days are only approximately correct. The larger fragments were counted as individual cells and the smaller ones disregarded. Similar conditions have been noted in other colostral milk and occasionally in milk from later periods of lactation.

A bacteriological examination of the milk of this animal was made by Mr. Ruehle in the same way that he made the examination for Chloe B. (No. 7). Samples were collected from each milking from March 13 to the evening milking of March 16. The average numbers of bacteria per cubic centimeter for the seven tests when the plates were incubated at room temperature were as follows: right front, 108; right hind, 9; left front, 9; left hind, 3; average of the four quarters, 32. When the plates were incubated for two days longer at 37 degrees C., the counts rose to the following averages: right

Table X — Cell Content of the Milk of Ruth F. B. B. (No 25).
(A Grade Jersey heifer which freshened March 13, 1911.)

Date.	Number of cells per c.c.	Milk.	Notes.
1911.		*Lbs.*	
March 13	1,145,000	3.0	Due to freshen April 18. Aborted during the night of March 12. Calf dead. Udder not caked or inflamed. Milk normal colostral milk. No blood evident.
	1,295,000	3.6	
March 14	1,320,000	5.5	Innumerable cell fragments in milk.
	?	5.9	Impossible to count because of fragmentary condition of cells.
March 15	375,000	7.7	
	360,000	6.1	Samples taken from each quarter gave the following counts. R. F. 320,000, R. H. 120,000, L. F. 230,000, L. H. 160,000. Middle milk.
March 16	150,000	8.0	Milk of normal appearance. Cell fragments still abundant in the milk.
	170,000	6.6	
March 17	95,000	8.3	
	65,000	8.0	
March 18	75,000	9.0	
	125,000	8.2	
March 19	105,000	9.6	
	110,000	7.9	
March 20	95,000	9.2	Milked by hand until the evening milking of March 20. After that by machine.
	45,000	7.8	
March 21	65,000	10.3	
	50,000	8.4	
March 22	65,000	10.5	
	85,000	8.6	
March 23	45,000	10.6	
	75,000	8.5	
March 24	35,000	10.5	
	25,000	8.0	

front, 218; right hind, 14; left front, 16; left hind, 5; average of the four quarters, 62.

These figures are all low when compared with those found by other investigators. An examination of the colonies on the agar plates showed a micrococcus to be present in the right front quarter of this cow which was apparently the same as that present in the left quarters of Chloe B. (No. 7), but this form was not present in large numbers. There were no streptococci which grew on the plates. The samples of milk from which the plates were made were incubated as before for 3 days at 37 degrees C. and then examined microscopically. No streptococci were found.

B. CELL CONTENT OF THE MILK OF INDIVIDUAL ANIMALS IN LATER PERIODS OF LACTATION.

The milk of four cows was studied in detail during a period of five weeks from Feb. 17 to March 22, 1911. Two of these were as normal animals as could be selected from the herd and two were abnormal in some respect. Table XI gives the detailed record of these examinations and the fluctuations are shown graphically in Graph II. The cell counts of the smears made for Millie of Geneva (No. 19) were made by Mr. Stidger. All of the rest of the work of testing these animals was done by the author of the paper.

Table XI.— Number of Cells Per Cubic Centimeter Found in the Milk of Four Cows During a Period of Five Weeks.

Numbers given in thousands per cubic centimeter.

Date	Hammond F. 1 (No. 15) machine milked.		Gerty F. 1 (No. 10) machine milked.		Mabel S. F. (No. 17) machine milked.		Millie of Geneva (No. 19) hand milked.	
	Number of cells.	Milk.	Number of cells.	Milk.	Number of cells.	Milk.	Number of cells.	Milk.
1911.		*Lbs.*		*Lbs.*		*Lbs.*		*Lbs.*
		6.8		5.7		4.4		
February 17.....	......	8.5	......	5.4	......	4.8	745	8.3
		7.7		4.4		3.6		
February 18.....	......	7.8	......	5.3	......	4.8	1,445	8.2
		8.0		5.0		4.1		
February 19.....	......	8.0	......	4.7	......	4.4	1,345	8.3
		6.0		4.4		3.8		
February 20.....	......	10.0	......	6.5	......	5.2	1,205	8.5
		6.0		4.9		3.4		
February 21.....	325	9.8	600	5.2	875	5.0	1,440	8.0
	380	6.3	515	3.6	640	4.4	755	10.8
February 22.....	400	8.2	325	5.2	905	4.3	1,065	7.4
	160	7.2	785	5.0	690	4.4	795	10.0
February 23.....	285	8.0	880	5.5	1,045	4.2	1,070	7.8
	195	7.3	670	4.7	545	3.1	765	10.0
February 24.....	185	6.3	225	5.0	660	5.0	705	8.0
	180	6.3	405	5.2	500	3.3	960	10.3
February 25.....	165	7.8	540	5.0	795	4.3	900	8.5

TABLE XI — NUMBER OF CELLS PER CUBIC CENTIMETER FOUND IN THE MILK OF FOUR COWS DURING A PERIOD OF FIVE WEEKS —(*Continued*).

Numbers given in thousands per cubic centimeter

Date.	Hammond F. 1 (No 15) machine milked.		Gerty F. 1 (No 10) machine milked.		Mabel S. F. (No 17) machine milked.		Millie of Geneva (No 19) hand milked.	
	Number of cells.	Milk.	Number of cells.	Milk.	Number of cells.	Milk.	Number of cells.	Milk.
1911.		*Lbs.*		*Lbs.*		*Lbs.*		*Lbs.*
	155	7.0	440	5.3	695	3.7	615	10.2
February 26.....	220	6.9	280	4.6	850	4.3	630	8.3
	325	6.6	365	5.0	625	3.8	1,020	9.9
February 27.....	325	6.9	385	4.3	1,030	4.0	970	8.3
	200	6.5	210	4.8	635	3.4	695	9.3
February 28.....	235	7.5	345	5.7	775	4.1	760	8.0
	260	6.5	455	3.6	495	3.2	710	9.8
March 1........	200	8.3	345	6.3	775	4.3	885	8.0
	220	6.8	490	5.0	445	3.3	995	9.4
March 2........	260	6.5	805	5.2	975	4.2	1,650	8.1
	185	6.6	850	3.3	290	3.0	1,140	9.8
March 3........	250	6.5	505	6.5	900	4.2	1,000	8.1
	205	6.5	1,090	3.1	870	3.4	865	9.4
March 4........	275	6.8	530	5.8	1,100	3.7	850	8.1
	150	7.5	700	5.5	790	4.1	745	9.6
March 5........	150	6.3	570	4.4	475	3.4	835	7.1
	205	6.2	400	4.9	860	3.8	830	9.6
March 6........	260	7.7	305	3.4	880	2.8	1,005	7.5
	285	7.0	380	4.8	605	4.0	705	9.5
March 7........	290	6.7	380	5.6	705	3.7	1,055	7.2
	250	6.3	675	4.1	1,365	3.3	900	9.0
March 8........	220	7.8	565	5.5	925	3.3	610	7.5
	115	5.8	730	4.0	725	4.0	825	9.3
March 9........	145	6.1	445	6.1	665	3.4	805	7.2
	200	6.5	570	3.9	940	3.3	710	9.6
March 10.......	640	8.3	445	4.9	1,085	3.6	470	7.0
	635	7.0	410	4.4	1,060	3.7	900	9.7
March 11.......	435	6.2	370	5.5	1,085	3.4	1,085	7.7
	160	7.0	320	3.6	500	3.5	875	8.3
March 12.......	290	6.3	310	4.3	540	3.4	1,020	7.4

TABLE XI.— NUMBER OF CELLS PER CUBIC CENTIMETER FOUND IN THE MILK OF FOUR COWS DURING A PERIOD OF FIVE WEEKS — (*Concluded*).

Numbers given in **thousands** per cubic centimeter.

Date.	Hammond F. 1 (No. 15) machine milked.		Gerty F. 1 (No. 10) machine milked.		Mabel S. F. (No. 17) machine milked.		Millie of Geneva (No. 19) hand milked.	
	Number of cells.	Milk.	Number of cells.	Milk.	Number of cells.	Milk.	Number of cells.	Milk.
1911.		*Lbs.*		*Lbs.*		*Lbs.*		*Lbs.*
	250	7.0	410	5.0	575	3.4	1,060	8.6
March 13.......	390	6.7	615	5.0	1,415	3.6	1,130	7.8
	350	6.3	520	4.0	1,010	3.1	1,115	9.3
March 14.......	305	6.6	370	5.3	580	3.7	1,555	8.0
	185	6.5	340	4.0	765	3.6	1,010	8.3
March 15.......	240	6.4	470	5.8	710	3.6	1,005	8.1
	285	5.7	715	4.2	420	2.8	880	9.8
March 16.......	235	7.5	700	5.4	630	3.9	1,015	7.5
	175	6.4	690	4.6	715	2.5	950	8.6
March 17.......	260	6.3	490	4.3	690	4.1	985	7.8
	165	6.5	500	3.0	625	3.0	1,060	9.3
March 18.......	160	6.9	490	6.5	375	3.1	1,000	7.9
	175	6.6	820	3.8	330	3.0	960	9.2
March 19.......	180	6.6	1,030	3.9	135	3.3	1,000	7.5
	285	5.6	800	5.7	190	3.1	930	9.3
March 20.......	230	7.7	1,175	4.8	600	3.6	1,090	7.5
	255	6.8	1,000	5.4	680	2.6	1,225	8.8
March 21.......	325	6.1	1,215	3.8	370	3.2	1,180	7.0
March 22.......	225	6.0	845	4.7	345	3.5	980	9.0
Averages....	253	....	497	....	705	....	958	.....

The records of the four animals are given in Table I on page 150. As will be seen from this table, Hammond F. 1 was a cow in her prime (5 years old) and had always had normal calvings and had never had any trouble with her udder previous to this time. Her last calf was born on August 27, 1910. The same statements are true of Gerty F. 1, except that she was 6 years instead of 5 years old. She calved on July 19, 1910.

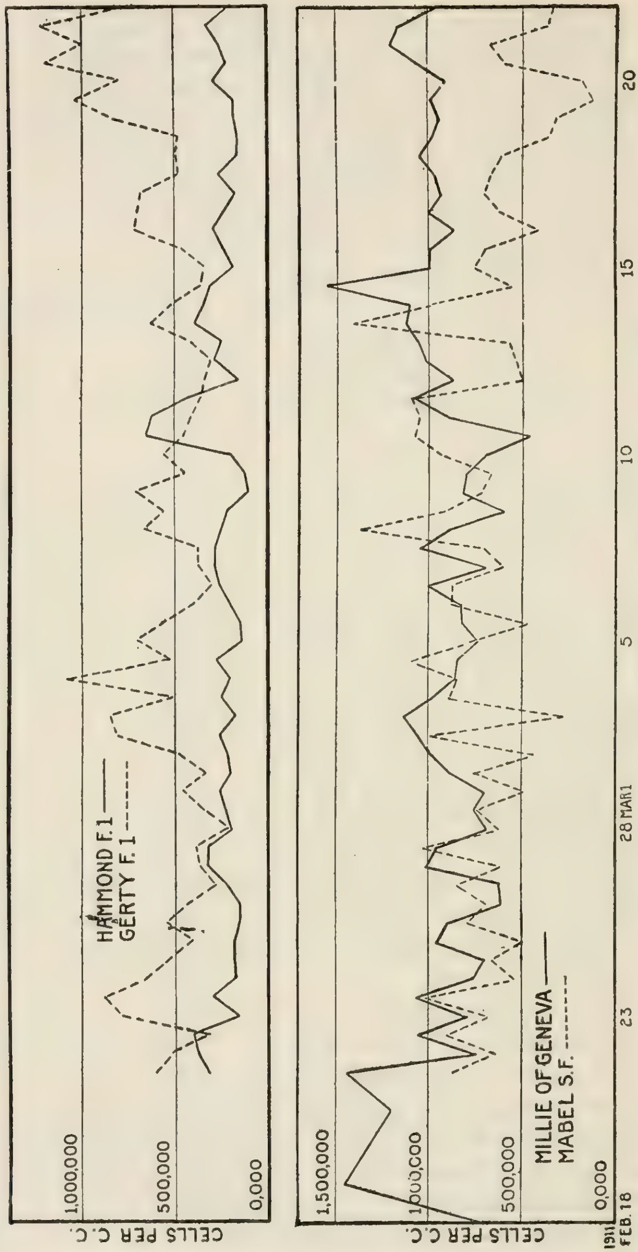
Mabel S. F. (No. 17) on the other hand, had aborted two calves, the last of these abortions having taken place on October 28, 1910. She was very nearly dry. She gave only a small quantity of milk and at times the smears which were made from her milk were found to be more or less soluble in alcohol so that it was difficult to make good preparations. This indicated some condition of her milk which was different from normal. The abnormality was not correlated in any way with fluctuations in the cell count.

Millie of Geneva (No. 19) had suffered from " spider in the teat " during the lactation period previous to the one in which these tests were made. The left hind quarter was seriously affected but finally returned to its normal condition except that the duct of this teat was more or less obstructed. She calved normally on September 18, 1910.

Graph II shows the fluctuations in cell counts of these cows much more clearly than the figures in the table. The upper part of this Graph shows the record of the two normal cows and the lower part the record of the two abnormal cows. The striking daily variations shown in these curves are seen to occur in all cases. The two normal cows maintain a lower average cell count than the two abnormal cows when the whole period is taken into consideration; but, if the last week of the period is considered by itself, this would not be the case, for Mabel S. F. shows a decidedly lower count than she had shown previously although she was approaching the end of her lactation period. At the same time, the cell count for Gerty F. 1 shows a decided increase in the cell content of her milk so that she had as high a cell count as any of the four cows during the last few days of the test. All of the cows show counts higher than 500,000 cells per cubic centimeter at some time during the period, although Hammond F. 1 usually shows counts of less than 250,000 cells per cubic centimeter.

There is a certain constancy in the number of cells discharged, which is maintained for days or weeks at a time but the indications are that more extended records would show that great fluctuations occur even in the case of the normal cows.

There is no evidence of the cyclic variations noted by Breed and Stidger in the case of two of the cows which they studied nor do the curves show any common characteristics so far as has been noted. The fact that the one hand-milked cow had a higher



Graph II.—Cell Content of Milk of Four Cows in Various Stages of Lactation.
Curves in upper portion from apparently normal cows; in lower portion from more or less abnormal cows.

average number of cells in her milk than the machine-milked cows is probably of no significance.

It is difficult to see how the abnormality noted in the case of Mabel S. F. could cause an increase in the number of cells discharged and it is probable that the two things were not related to each other in any way. Since the average number of cells discharged (705,000 per cubic centimeter) is not as high as the average number of cells given for all of the cows examined (868,000 per cubic centimeter) and is not decidedly higher than the average number found in the case of other apparently normal cows in the same herd (see Table III), there is little reason for regarding the discharge of this number of cells as abnormal. Moreover Wilson did not note anything especially interesting in the bacterial flora of the udder of this cow in several examinations which he made during the previous summer. (See Technical Bulletin 27, Table X.) The predominant organism was the same as the one which has already been mentioned in connection with Chloe B. (page 151) and Ruth F. B. B. (page 153) which had the group number M. 211.2233033. None of the tests made in March, April or May, 1910, showed bacterial counts higher than 176 per cubic centimeter. Among the July, 1910, tests, one showed an average of 1100 per cubic centimeter for the left front quarter of this cow. The other quarters all gave low counts.

In the case of Millie G. there is reason for believing that there was a relation between the relatively high cell count (958,000 per cubic centimeter) and her previous udder trouble. No tests were made at this time to determine whether the high cell count was caused by an excessive discharge of cells from the quarter which had been most seriously affected (left hind), but it is quite possible that this was the case. Table X in Technical Bulletin No. 27 shows the organisms which Wilson isolated from this cow's udder. None of these were streptococci but a study of his notes shows that he failed to isolate the predominating organism present in all but the left hind quarter. This organism was present in large numbers, that is the bacterial counts frequently exceeded 1,000 per cubic centimeter, and sometimes showed such large numbers of colonies on the plate that they could not be counted. The colonies were small, gave a sour smell to the plates and appeared in practically pure culture. A culture isolated from the right hind

quarter on February 7, 1911, was lost because of its failure to grow. A culture of similar appearance isolated in May, 1911, from the right front quarter, which may or may not have been the same, gave the group number M. 211.2223032 but showed no tendency to form chains.

The organism present in the left hind quarter was a yeast with the group number 212.2332033 and occurred in practically pure-culture in all of the plates made from this quarter. A search for this organism made in December, 1913, by technique similar to that used by Wilson, failed to show this organism present in the left hind quarter though scattered colonies of a similar yeast made their appearance on plates made from other quarters of the udder.

None of these cows show as extreme conditions as those noted by Breed and Stidger [42] in their similar studies. They examined samples of milk from three apparently normal cows selected at random from a herd in Göttingen, Germany, daily for a period of four weeks. One cow (No. 54) gave an average count of 535,000 cells per cubic centimeter while another (No. 55) gave an average count of 2,070,000 cells per cubic centimeter. This latter cow showed marked fluctuations in the number of cells present in her milk, the numbers varying from 885,000 to 5,975,000 cells per cubic centimeter.

In marked contrast to this, Cow No. 56 showed very few cells present in the milk of three quarters of her udder while the milk of the fourth quarter showed a cell content fluctuating between 230,000 and 1,110,000 cells per cubic centimeter. The contrast between the milk of these two cows was so great that " if the whole number of cells discharged by the right hind quarter of Cow 56 in the 36 milkings tested had been discharged at a *single milking* and that in a liter of milk instead of in the $1\frac{3}{4}$ liters actually secreted, the number of cells would have been approximately 2,000,000 per cubic centimeter, that is a number which was the average number of cells found in the milk of Cow 55. In the extreme case, one quadrant of Cow 55 liberated almost as many cells at a *single milking* as the hind quarter of Cow 56 would have done in the *half of an entire lactation period* if the same low rate found in the period tested prevailed." No bacteriological examinations of the udder were made for any of these cows.

[42] See footnote 1.

C. CELL CONTENT OF THE MILK OF ANIMALS AT THE END OF THE LACTATION PERIOD.

Several investigators have reported that the number of cells discharged is greatly increased at the end of the lactation period. These statements are based on very incomplete and unsatisfactory data, as pointed out by Breed and Stidger.[43] Some further tests bearing on this point have been made which are summarized in Table XII. These tests, even combined with previous tests reported by other investigators, are still insufficient to show what the real conditions are. There are several of the records given in Table XII which are very high and above the normal for the cows in question, but in eleven out of the eighteen tests given the number of cells found was less than the average number found during the height of the lactation period and in three cases so few cells were present that it was difficult to find any at all.

TABLE XII — CELL CONTENT OF MILK OF ANIMALS NEAR THE END OF THEIR LACTATION PERIOD.

No.	NAME.	Date of test.	Number of cells.	Milk.	*	Milked once a day on these dates.	Milked once on these dates.
		1911.		*Lbs.*		1911	1911
1	Anna G.	7-26/27	15,000	10.8	13	8-24— 9-7	9-9
2	Carey of Station	6-25/26	50,000	5.6	0	6- 7— 6-17	6-19, 20, 22, 24, 26
5	Carey Fairy	6-25/26	170,000	5.3	35	7- 6— 7-21	7-23
8	Dolly F. B. B.	6-25/26	2,500	3.1	2	6-15— 6-26	6-28, 7-1
9	Dotshome Carey	6-25/26	515,000	5.1	0	6- 6— 6-16	6-19, 21, 23, 26
10	Gerty F. 1	6-25/26	505,000	4.1	2	6-15— 6-26	6-28, 7-1
12	Gerty F. 2	6-25/26	450,000	4.0	2	6-19— 6-26	6-28, 7-1
13	Gerty F. 3	6-25/26	2,500	9.8	5	6-20— 6-30	7-2, 4
14	Hammond 2	8-30/31	2,160,000	11.1	10+	8-26— 9- 9	9-11, 13, 16, 19, 22, 25, etc.
17	Mabel S. F.	5- 7/ 8	90,000	2.8	40	5-21— 5-27	5-29, 30
19	Millie of Geneva	7-26/27	905,000	7.6	13	7-24— 8- 8	8-10
20	Millie F.	6- 1/ 2	650,000	2.6	21	6-10— 6-13	
23	Nora F. B. B.	8-30/31	2,500	1.5	12	9- 5— 9- 6	
		1913.				1913	1913
16	Hammond F. 2	11-12	1,225,000	2.0	9	11- 6—11-19	11-22
19	Millie of Geneva	10-18	16,950,000	1.0	0	10-10—10-15	10-18
26	Carey Fairy Queen	11-12	1,710,000	0.0	0	10-31—11- 7	Stripped 11-12
27	Oxford Millie F. B. B.	11-12	1,160,000	0.0	0	11- 3—11- 8	Stripped 11-12
28	Mabel S. F. B. B.	12- 3	6,740,000	0.0	0	11-23—11-28	Stripped 12-3

* Number of times milked after test was made.

Yet, on the other hand, the record given for Millie G. on November 18, 1913, of 16,950,000 cells per cubic centimeter is the highest reported in this bulletin for mixed milk. It should be noted that this was taken from the very last milking and that this cow was

[43] See footnote 1.

one which had had udder trouble three years previous to this test and had always given relatively high cell counts even during the height of her lactation period. Several of the highest counts given for the other animals were obtained from milk drawn four or five days after milking had really been discontinued.

D. SUMMARY OF CELL COUNTS ACCORDING TO MONTH OF LACTATION.

All of the cell counts of the mixed milk of individual animals which have been made in this or previous investigations have been

TABLE XIII — CELL COUNTS ARRANGED ACCORDING TO MONTH OF LACTATION.

Numbers given represent **thousands** of cells per cubic centimeter.

	Month of Lactation.													
	Ia.*	Ib.†	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.
1	9,105	370	6,950	240	65	1,330	705	410	815	1,915	500	265	815	50
2	2,485	130	3,440	395	145	390	2,040	975	1,210	550	130	15	940	1,050
3	1,535	470	165	555	135	640	195	1,370	160	895	2,720	430	2	.....
4	3,925	345	235	205	615	95	65	50	500	725	1,040	440	575	.....
5	900	560	3,810	250	445	840	90	530	720	760	2	890	505	.....
6	3,300	3,860	690	1,190	455	400	735	2,125	410	495	145	390	2	.....
7	.....	165	850	405	930	500	15	180	580	500	60	450	2,160	.....
8	.....	625	305	165	135	650	30	85	715	910	170	120	480	.....
9	.....	770	765	1,150	70	105	350	2	305	490	620	820	16,950	.....
10	.....	685	10	805	240	1,025	265	680	1,100	585	2	350	.....	.....
11	.....	165	35	65	430	195	400	90	5,340	1,600	325	1,225	.....	.....
12	.....	1,170	20	45	460	0	240	165	1,305	1,340	105	905	.....	.....
13	.....	20	85	450	20	50	220	1,005	475	3,500	2	1,710	.....	.....
14	.....	725	385	30	425	420	305	295	865	370	380	1,160	.....	.....
15	.....	10	45	90	75	15	565	2	10	10	350	6,740	.....	.....
16	.....	350	280	1,990	745	515	1,095	130	30	75	340	.....	.....	.....
17	.....	80	215	50	10	785	545	425	115	80	175	.....	.....	.....
18	.....	.....	10	425	1,275	1,170	160	190	1,475	355	860	.....	.....	.....
19	.....	.....	.....	200	260	5	600	410	20	15	1,500	.....	.....	.....
20	.....	.....	.....	20	.....	1,005	10	255	125	460	790	.....	.....	.....
21	.....	.....	.....	820	.....	15	135	555	240	520	450	.....	.....	.....
22	.....	.....	.....	.....	.....	.....	.....	925	65	415	.....	.....	.....	.....
23	.....	.....	.....	.....	.....	.....	.....	940	190	1,020	.....	.....	.....	.....
24	.....	.....	.....	.....	.....	.....	.....	400	485	985	.....	.....	.....	.....
25	.....	.....	.....	.....	.....	.....	.....	575	430	70	.....	.....	.....	.....
26	.....	.....	.....	.....	.....	.....	.....	780	5	390	.....	.....	.....	.....
27	.....	.....	.....	.....	.....	.....	.....	240	115	1,435	.....	.....	.....	.....
28	.....	.....	.....	.....	.....	.....	.....	.....	235	595	.....	.....	.....	.....
29	.....	.....	.....	.....	.....	.....	.....	.....	110	1,365	.....	.....	.....	.....
30	.....	.....	.....	.....	.....	.....	.....	.....	375	1,360	.....	.....	.....	.....
31	.....	.....	.....	.....	.....	.....	.....	.....	995	470	.....	.....	.....	.....
32	.....	.....	.....	.....	.....	.....	.....	.....	70	160	.....	.....	.....	.....
33	.....	.....	.....	.....	.....	.....	.....	.....	830	.....	.....	.....	.....	.....
34	.....	.....	.....	.....	.....	.....	.....	.....	1,052	.....	.....	.....	.....	.....
35	.....	.....	.....	.....	.....	.....	.....	.....	650	.....	.....	.....	.....	.....
36	.....	.....	.....	.....	.....	.....	.....	.....	10	.....	.....	.....	.....	.....
37	.....	.....	.....	.....	.....	.....	.....	.....	1,360	.....	.....	.....	.....	.....
38	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....
Aver.	3,542	617	1,016 ‡667	454	360	483	417	511	618	763	508	1,061 ‡655	2,492 ‡685	550

* Counts given in this column were obtained from cows during the first three days of lactation.
† Counts given in this column were obtained from cows during the first month of lactation after the first three days of lactation.
‡ These averages do not include the highest count of the column above.

arranged in Table XIII according to the month of lactation. This gives a total of 246 tests made on 126 different cows of different breeds and from widely different regions. All of these cell counts except those in Column Ia and a few in Columns XI and XII were made from milk sufficiently normal in appearance to have been used. Three or more of the cows tested had had udder troubles at some time or other and as many as six possibly tubercular animals are included.

It is seen at once from the averages that even this number of tests is insufficient to show what the real conditions are. The differences between the numbers averaged are so great that a few large counts very materially affect the averages. It seems clear that the cell counts of the first three days of lactation average much higher than those of later periods although equally high cell counts are seen in almost all of the later periods. When the counts are separated into two groups at the 500,000 per cubic centimeter mark, it is found that the ratio between the number of counts under this mark to the number of counts over this mark during the first six months of lactation (exclusive of counts obtained from colostral milk) is 100:52. The similar ratio for the counts obtained during the second six months is 100:82. That is, the majority of the high cell counts here given occurred during the latter part of the lactation period.

The lowest average cell counts given in Table XIII occur during the months when the greatest amount of milk is secreted (third to seventh month). Inasmuch as the cell counts are all given on the cubic centimeter basis and inasmuch as the numbers of cells found during the latter portion of the lactation period when the total amount of milk secreted is small are not decidedly different from those found during the earlier portion, it is evident that the total number of cells discharged from the udder at a single milking averages less during the latter portion of the lactation period.

III. EFFECT OF THE VACUUM COW MILKER ON THE CELL COUNT.

Because of the fact that vacuum milking machines have frequently been accused of causing so-called " leucocytosis " and also because the question is frequently asked whether high vacuums do not suck blood out of the interior of the udder, three series of observations were

made bearing on this point. These observations are of greater importance because of the fact that all of the machine milkers now being actively pushed on the American market are operated either entirely or partially by means of a vacuum.

Experiments with the Burrell-Lawrence-Kennedy cow milker have been in progress at the station since 1907 so that the operation of these machines during the time of the experiments here described involved no unaccustomed duties for the employees in the dairy and the animals experimented upon were accustomed to being milked in this manner. The machines milked the cows thoroughly and no trouble in operating them occurred during the course of the experiments. The makers of this machine recommend that it be operated with a vacuum of approximately one half an atmosphere (15 inches as indicated by a mercury column). This recommendation is based on a large amount of careful observation and experimentation by the makers and users of these machines.

Three lines of evidence were obtained which had a bearing on the problem whether or not this type of cow milker influences the cellular content of the milk. First, an experiment was carried out during a period of six weeks on three animals, using three other animals as controls, in which the effect of gradually increasing the vacuum from 14.5 inches to 19.5 inches was studied. Second, two cows were milked for five days by hand and then for five days by machine and the milk from each milking was examined to see whether any change in the cellular content of the milk occurred which could be attributed to this change in the method of milking. Third, the cellular content of the milk of all of the machine-milked cows in the herd was compared with the cellular content of the milk of the hand-milked cows.

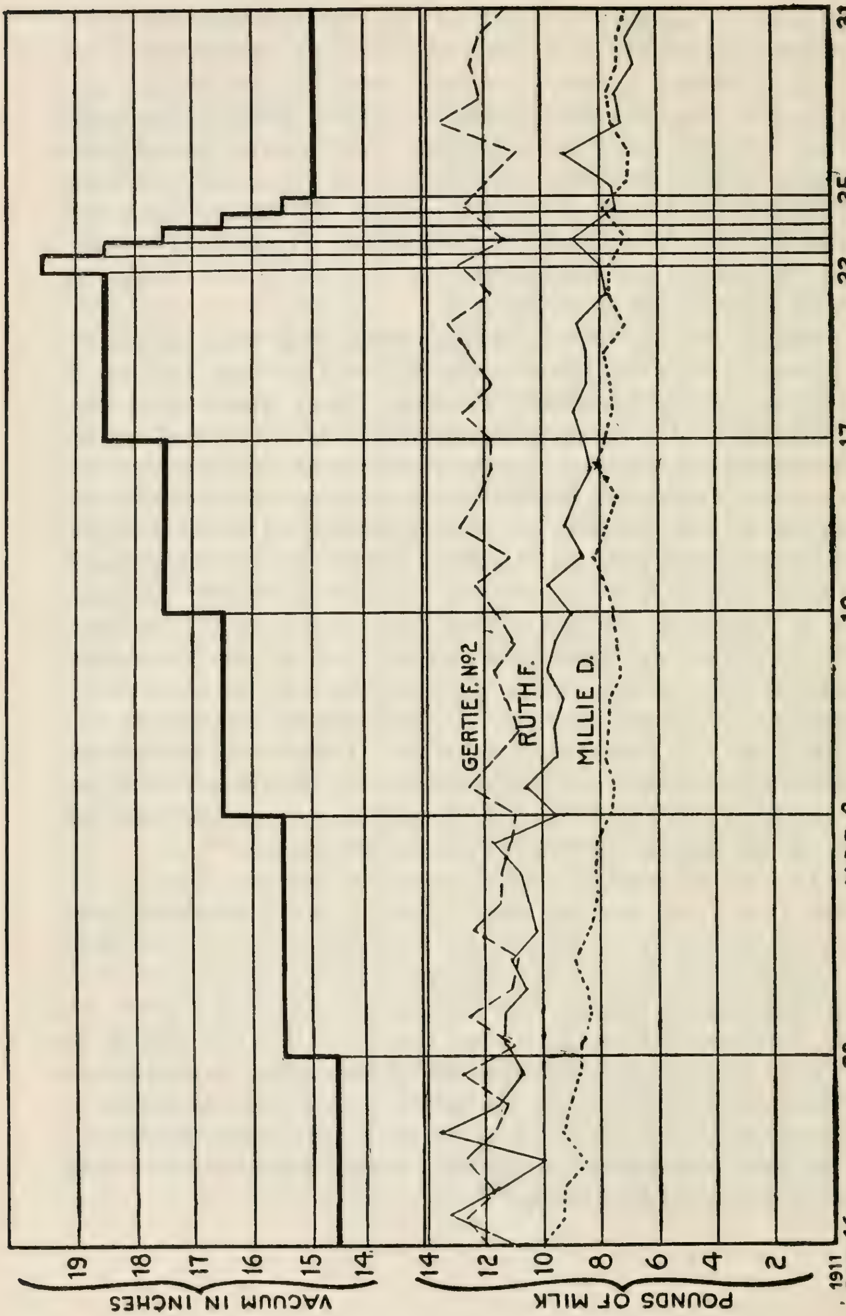
A. EXPERIMENTS TO DETERMINE THE INFLUENCE OF INCREASING THE VACUUM ON THE CELL CONTENT OF THE MILK OF MACHINE-MILKED COWS.

The three cows chosen for the experiment were Gerty F. 2 (No. 12), Millie D. (No. 18), and Ruth F. (No. 24), while Gerty F. 1 (No. 10), Hammond F. 1 (No. 15), and Mabel S. F. (No. 17) were used as controls. The three experimental animals represented as varied conditions in regard to the cellular content of their milk as could

be found in the herd. Gerty F. 2 (No. 12) gave milk which contained relatively few cells. Ruth F. (No. 24) gave milk which contained a medium number of cells and Millie D. (No. 18) gave milk containing large numbers of cells, the number being usually higher than 1,000,000 per cubic centimeter. The control animals were chosen to duplicate these conditions so far as possible. Of these, Hammond F. 1 (No. 15) gave the lowest cell counts, Gerty F. 1 (No. 10) medium counts and Mabel S. F. (No. 17) the highest counts. The duplication in conditions was not exact but proved satisfactory for the purposes of the experiment.

Samples of milk from the animals which were to be used in the experiment were examined during the week previous to Feb. 23, 1911, in order to determine the number of cells present under usual conditions. At the evening milking of February 23, the vacuum was increased from the usual amount (14.5 inches) to 15.5 inches. At the evening milking of March 3 it was again increased to 16.5 inches and so to 17.5 inches at the evening milking of March 10. The vacuum was placed at 18.5 inches at the evening milking of March 16 and kept there till the evening of March 19 when it was raised to 19.5 inches for this one milking only. It then became necessary to discontinue the experiment and the vacuum was lowered one inch at each milking during the four succeeding milkings and so returned to 14.5 inches. This change in the vacuum and its relation to the milk flow is shown in Graph III taken from Bulletin 353. The control animals were milked continuously at 14.5 inches vacuum. Samples of milk were taken from the pail at every milking from each of the six animals and the cell content determined.

The vacuum gauge was tested out during the experiment to make sure that it was working properly and a careful watch was kept on the animals to see whether the increased vacuum caused udder troubles of any sort. " Not only was there no demonstrable effect of the change of vacuum upon the flow of milk but also there were no objectionable local effects upon the cows. It is true that at the close of the milking process with the higher vacuum there was some difference of opinion as to the presence of a slight congestion at the extremity of the teats of Ruth F. Whatever abnormality may have been present passed away within a few minutes leaving no objectionable after-effects."



Graph III.—Relation of Vacuum to Milk Flow.

The records of the cell counts made on these six cows are given in Table XIV and they are shown graphically in Graph IV.

Table XIV.— Effect of Increasing the Vacuum on the Cellular Content of the Milk of Three Cows.

Number of cells given in thousands per cubic centimeter

Experimental Animals.						Date.	Control Animals.					
Ruth F.		Gerty F. 2.		Millie D.			Hammond F. 1.		Gerty F. 1.		Mabel S. F.	
Number of cells.	Milk.	Number of cells.	Milk.	Number of cells.	Milk.		Number of cells.	Milk.	Number of cells.	Milk.	Number of cells.	Milk.
	Lbs.		Lbs.		Lbs.	1911.		Lbs.		Lbs.		Lbs.
Vacuum used = 14.5 in.							Vacuum used = 14.5 in.					
160	5.0	130	4.0	......	4.8	Feb.* 10	......	....	......	....	......	....
....	4.1	......	5.8	1,360	4.8	Feb. 13	......	....	......	....	......	....
220	5.0	135	5.5	1,005	4.3	Feb. 14	420	7.3	295	6.0	1,200	5.2
305	6.2	145	5.5	1,295	4.3	Feb. 15	......	....	......	....	......	....
335	4.6	165	5.8	880	5.0	Feb. 16	......	....	......	....	......	....
415	5.3	230	6.3	745	4.5	Feb. 17	......	....	......	....	......	....
....	5.5	......	6.4	1,350	4.5	Feb. 18	......	....	......	....	......	....
460	3.2	195	5.5	1,235	3.5	Feb. 19	......	....	......	....	......	....
500	5.7	170	5.8	1,020	4.8	Feb. 20	......	....	......	....	......	....
355	5.3	140	5.4	690	4.3	Feb. 21	325	9.8	600	5.2	875	5.0
360	5.5	170	7.0	780	4.3	Feb. 22	380	6.3	515	3.6	640	4.4
265	5.3	155	5.8	1,200	4.4	....	400	8.2	325	5.2	905	4.3
465	5.4	215	5.7	1,350	5.0	Feb. 23	160	7.2	785	5.0	690	4.4
Vacuum used = 15.5 in.							Vacuum used = 14.5 in.					
335	5.8	265	5.3	2,155	3.6	....	285	8.0	880	5.5	1,045	4.2
320	5.9	115	4.8	1,365	4.4	Feb. 24	195	7.3	670	4.7	545	3.1
285	5.4	185	7.6	1,365	3.8	....	185	6.3	225	5.0	660	5.0
205	5.7	200	4.0	1,130	4.4	Feb. 25	180	6.3	405	5.2	500	3.3
435	5.0	250	7.1	1,100	4.0	....	165	7.8	540	5.0	795	4.3
315	6.0	185	5.0	1,160	5.0	Feb. 26	155	7.0	440	5.3	695	3.7
335	5.0	150	5.9	1,035	3.8	....	220	6.9	280	4.6	850	4.3
345	5.4	215	6.2	1,165	4.7	Feb. 27	325	6.6	365	5.0	625	3.8
370	4.8	330	6.0	1,200	3.6	....	325	6.9	385	4.3	1,030	4.0
360	5.5	105	5.2	875	4.1	Feb. 28	200	6.5	210	4.8	635	3.4
460	5.1	255	6.3	1,355	3.8	....	235	7.5	345	5.7	775	4.1
320	5.4	130	4.4	990	4.2	Mar. 1	260	6.5	455	3.6	495	3.2
435	5.5	265	7.0	1,005	3.9	....	180	8.3	345	6.3	775	4.3
425	5.8	190	4.8	1,380	4.0	Mar. 2	200	6.8	490	5.0	445	3.3
405	6.0	175	6.3	1,795	4.0	....	240	6.5	805	5.2	975	4.2
350	4.7	125	5.0	1,420	4.0	Mar. 3	185	6.6	850	3.3	290	3.0

*Test made from evening milking where only one test is given per day.

TABLE XIV — (*Continued*).

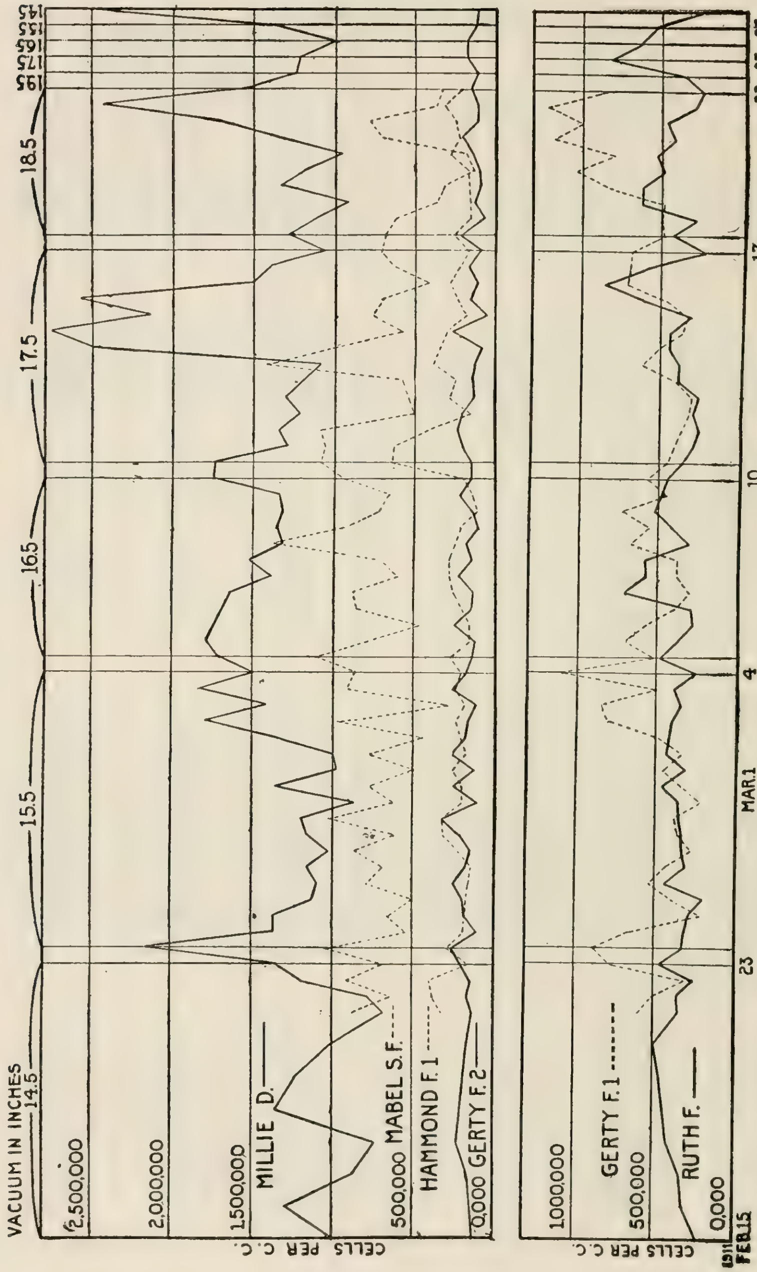
EXPERIMENTAL ANIMALS.						Date.	CONTROL ANIMALS.					
RUTH F.		GERTY F. 2.		MILLIE D.			HAMMOND F. 1.		GERTY F. 1.		MABEL S. F.	
Number of cells	Milk.	Number of cells	Milk.	Number of cells.	Milk.		Number of cells.	Milk.	Number of cells.	Milk.	Number of cells.	Milk.
	Lbs.		*Lbs.*		*Lbs.*	1911.		*Lbs.*		*Lbs.*		*Lbs.*
VACUUM USED = 16.5 IN.							VACUUM USED = 14.5 IN.					
390	4.9	265	5.8	1,830	3.5	....	250	6.5	505	6.5	900	4.2
265	5.7	195	5.1	1,500	4.3	Mar. 4	205	6.5	1,090	3.1	870	3.4
480	5.0	145	7.3	1,715	3.1	....	275	6.8	530	5.8	1,100	3.7
375	4.8	130	6.0	1,790	4.6	Mar. 5	150	7.5	700	5.5	790	4.1
290	4.8	255	5.7	1,750	3.2	....	150	6.3	570	4.4	475	3.4
295	5.4	150	5.4	1,695	3.9	Mar. 6	205	6.2	400	4.9	860	3.8
1,705	4.3	145	5.5	1,550	3.8	....	260	7.7	305	3.4	880	2.8
575	5.6	230	4.2	1,395	4.3	Mar. 7	285	7.0	380	4.8	605	4.0
580	3.7	155	7.1	1,530	3.4	....	290	6.7	380	5.8	705	3.7
310	5.1	185	5.6	1,335	3.8	Mar. 8	250	6.3	675	4.1	1,365	3.3
415	4.8	110	6.1	1,350	3.6	....	220	7.8	565	5.5	925	3.3
520	5.7	155	5.9	1,325	3.8	Mar. 9	115	5.8	730	4.0	725	4.0
475	3.9	225	5.1	1,340	3.5	....	145	6.1	445	6.1	665	3.4
445	5.5	160	5.3	1,745	4.2	Mar. 10	200	6.5	570	3.9	940	3.3
VACUUM USED = 17.5 IN.							VACUUM USED = 14.5 IN.					
355	3.4	155	6.4	1,740	3.3	....	640	8.3	445	4.9	1,085	3.6
295	5.6	210	5.4	1,305	4.5	Mar. 11	635	7.0	410	4.4	1,060	3.7
260	4.3	220	6.9	1,345	3.3	....	435	6.2	370	5.5	1,085	3.4
295	4.5	210	8.3	1,235	4.5	Mar. 12	160	7.0	320	3.6	500	3.5
265	4.0	140	6.8	1,305	3.6	....	290	6.3	310	4.3	540	3.4
400	5.0	155	6.1	......	4.0	Mar. 13	250	7.0	410	5.0	575	3.4
390	4.4	140	6.6	1,090	3.9	....	390	6.7	615	5.0	1,415	3.6
445	4.3	95	5.6	2,465	4.0	Mar. 14	350	6.3	520	4.0	1,010	3.1
450	4.5	270	6.5	2,765	3.3	....	305	6.6	370	5.3	580	3.7
320	4.2	55	5.2	2,150	4.4	Mar. 15	185	6.5	340	4.0	765	3.6
605	4.0	170	6.6	2,580	3.7	....	240	6.4	470	5.8	710	3.6
845	4.4	120	4.8	1,510	4.1	Mar. 16	285	5.7	715	4.2	420	2.8
VACUUM USED = 18.5 IN.							VACUUM USED = 14.5 IN.					
595	4.1	175	7.1	1,405	3.6	....	235	7.5	700	5.4	630	3.9
235	4.7	110	6.2	1,065	4.0	Mar. 17	175	6.4	690	4.6	715	2.5
425	4.1	230	6.5	1,285	3.4	....	260	6.3	490	4.3	690	4.1
290	4.2	85	5.3	1,125	4.1	Mar. 18	165	6.5	500	3.0	625	3.0
625	4.1	140	6.6	925	3.5	....	160	6.9	490	6.5	375	3.1
625	4.8	115	4.3	1,330	4.2	Mar. 19	175	6.6	820	3.8	330	3.0
495	3.5	105	7.2	1,190	3.6	....	180	6.6	1,030	3.9	135	3.3
540	4.4	150	6.8	965	3.8	Mar. 20	285	5.6	800	5.7	190	3.1
425	4.4	215	6.7	1,355	3.4	....	230	7.7	1,175	4.8	600	3.6

Table XIV — (*Concluded*).

Experimental Animals.						Date.	Control Animals.					
Ruth F.		Gerty F. 2.		Millie D.			Hammond F. 1.		Gerty F. 1.		Mabel S. F.	
Number of cells.	Milk.	Number of cells.	Milk.	Number of cells.	Milk.		Number of cells.	Milk.	Number of cells.	Milk.	Number of cells.	Milk.
	Lbs.		*Lbs.*		*Lbs.*	1911.		*Lbs.*		*Lbs.*		*Lbs.*
Vaccum used = 18.5 in.							Vaccum used = 14.5 in.					
465	4.2	125	5.3	1,710	4.3	Mar. 21	255	6.8	1,000	5.4	680	2.6
305	3.5	125	6.6	2,440	3.4	....	325	6.1	1,215	3.8	370	3.2
255	4.4	160	6.0	1,575	4.1	Mar. 22	225	6.0	845	4.7	345	3.5
Vacuum used = 19.5 in.												
370	3.5	135	7.0	1,255	4.1	....	......	....	......	....	......	....
Vacuum used = 17.5 in.												
820	4.4	185	4.6	1,230	4.0	Mar 23	......	....	......	....	......	....
Vacuum used = 16.5 in.												
645	4.6	190	7.0	1,015	4.0	....	......	....	......	....	......	....
Vacuum used = 15.5 in.												
540	3.9	135	6.0	1,385	3.1	Mar 24	......	....	......	....	......	....
Vacuum used = 14.5 in.												
270	3.5	125	6.8	2,400	4.8	....	......	....	......	....	......	....
Averages for Each of the Above Periods.												
†350	5.6	170	6.2	1,080	4.5	Feb. 10–23	‡315	7.9	555	4.75	780	4.5
360	5.4	195	5.6	1,280	4.1	Feb. 23 to Mar. 3	220	6.9	480	4.9	700	3.8
365	4.9	180	5.7	1,560	3.9	Mar. 3–10	215	6.7	560	4.85	840	3.6
410	4.4	155	6.2	1,770	4.2	Mar. 10–16	350	6.6	440	4.7	810	3.4
440	4.2	145	6.2	1,360	3.8	Mar. 16–22	220	6.6	805	4.7	470	3.2
370	3.5	135	7.0	1,255	4.1	Mar. 22	......	....	......	....	......	....

†Vacuum increased 1 in. with each period beginning at 14.5. in. and increasing to 19.5 in.

‡Vacuum used = 14.5 in.



GRAPH IV.—CELL CONTENT OF MILK OF THREE EXPERIMENTAL AND THREE CONTROL (DOTTED LINES) ANIMALS.
Changes in vacuum indicated do not apply to control animals.

The comparison of the experimental animals with their controls may be started with a discussion of Gerty F. 2 (experimental animal) with Hammond F. 1 (control). These two animals were the most satisfactory in that they both gave milk having a fairly constant cell content and were not so near the end of their period of lactation as the other animals. Gerty F. 2 was in the seventh and eighth month of her period of lactation at the time and gave an almost constant amount of milk. The cell content of her milk showed a slight average decrease after the first week with no marked fluctuations (see Table XIV and Graph IV, upper portion). Hammond F. 1, her control, had calved three weeks later than Gerty F. 2, and gave a gradually decreasing amount of milk. The cell content of her milk was constantly somewhat higher and more fluctuating than that of Gerty F. 2.

A comparison between Ruth F. (experimental animal) with Gerty F. 1 (control) shows that Ruth F. gave a gradually decreasing amount of milk while Gerty F. 1 maintained a practically constant amount to the end of the experiment (see Table XIV and Graph IV, lower portion). This was to have been expected as Ruth F. was within one month of the end of her period of lactation while Gerty F. 1 was milked for two and one-half months longer. Ruth F. gave milk which contained a gradually increasing number of cells but the percentage of increase was not great nor were the fluctuations as many nor as great as in her control animal. Gerty F. 1, the control, showed a marked increase in the number of cells in her milk toward the end of the experiment and in several instances gave milk containing over 1,000,000 cells per cubic centimeter.

None of these four animals showed any abnormal condition of milk or of health at any time during the experiment nor for months thereafter. Ruth F. suffered from milk fever at her next calving period and Gerty F. 1 had a skin disease during the following summer, but these conditions cannot be connected in any way with the experiments here outlined.

Millie D. (experimental animal) and Mabel S. F. (control) both proved to be animals which were not entirely normal in every respect and, therefore, in one way, not so satisfactory for the purposes of this experiment but on account of their abnormality, more interesting for study than the other animals. Millie D. was in the ninth and tenth month of her period of lactation but had only just become

pregnant at the time this experiment began although she had been served a number of times previously. She was giving a small amount of milk which decreased slightly during the experiment. She was dried off six or seven weeks after the end of the experiment. Her next calf was dropped in October, 1911. Millie D.'s milk contained large numbers of cells at all times and showed some marked fluctuations (see Table XIV and Graph IV, upper portion). At times it was decidedly salty to the taste and did not stick well to the slide when the smears were made for counting the cells. It can scarcely be claimed, however, that these conditions were due to the experiment as they are common conditions in the milk of cows which are near the end of their period of lactation. Moreover, the conditions in the control animal were somewhat similar. Mabel S. F. (control) had aborted her calf on October 28th of the fall previous and was giving only a small quantity of milk, the amount of which showed a gradual decrease during the experiment. She, like Millie D., was milked but seven or eight weeks after the experiment closed. The cell content of her milk was never as great as that of Millie D.'s milk and showed a marked decrease toward the end. The same difficulty in making smears of her milk was met with as in the case of Millie D., but no salty taste was noted.

If the records of the experimental animals are compared among themselves, it is seen that they present equally contradictory conditions. Thus the record of Ruth F. shows a gradual increase in the number of the cells in her milk during the period when the vacuum was being increased 1 inch per week. However the record of Gerty F. 2 shows that the number of cells in her milk gradually decreased during the same period, while Millie D.'s record shows an increase in the number of cells in her milk up to the last week of the experiment when a sharp decrease occurs just at the time when the vacuum used was greatest in amount. It is especially noteworthy that exactly contradictory conditions were found in the three experimental animals during the last few days, when the vacuum was being decreased one inch at each successive milking. Graph IV shows, that during these days, the curve for Ruth F. reaches a maximum, the curve for Millie D. a minimum while that for Gerty F. 2 maintains a practically straight course.

It is thus clearly seen that these changes in the vacuum did not influence the number of the cells discharged and there is no indication that more extensive experimentation would have done so.

F. EXPERIMENT TO SHOW THE EFFECT ON THE CELL CONTENT OF THE MILK WHEN THE ANIMALS WERE MILKED FIRST BY HAND AND LATER BY MACHINE.

Two animals freshened during the period in which these studies were made and the opportunity was taken to make a detailed study of the changes in cell content of their milk during the first few days of lactation. These observations are reported on pages 166–175. After milking one of the cows, Chloe B. (No. 7), for seventeen and one-half days and the other, Ruth F. B. B. (No. 25), for seven and one-half days by hand, both were put on the machine. Records are here given for the period just before and just after the change during which time both cows were apparently discharging cells at a normal rate.

Table XV.— Cell Counts of Two Cows Milked First by Hand and Later by Machine.

Numbers given per cubic centimeter.

Date.	Chloe B. (No. 7).		Ruth F. B. B. (No. 25).	
	Number cells.	Milk.	Number cells.	Milk.
		Lbs.		*Lbs.*
HAND MILKED.				
March 16	*660,000	15.8	....	....
	495,000	13.4	....	....
March 17	155,000	15.2	†95,000	8.3
	395,000	14.5	65,000	8.0
March 18	760,000	15.7	75,000	9.0
	1,050,000	14.6	125,000	8.2
March 19	320,000	15.3	105,000	9.6
	480,000	14.3	110,000	7.9
March 20	275,000	15.0	95,000	9.2
MACHINE MILKED AT A VACUUM OF 14.5 INCHES.				
	115,000	15.6	45,000	7.8
March 21	110,000	15.1	65,000	10.3
	170,000	12.5	50,000	8.4
March 22	440,000	15.1	65,000	10.5
	225,000	13.8	85,000	8.6
March 23	215,000	16.0	45,000	10.6
	200,000	15.4	75,000	8.5
March 24	330,000	14.8	35,000	10.5
	245,000	14.6	25,000	8.0
Average of hand-milked samples	510,000	......	95,000	....
Average of machine-milked samples	230,000	......	55,000	....

* Twenty-seventh milking. † Ninth milking.

The number of cells in the milk of each cow showed a decided decrease at the first milking after the machine was used. The comparative averages of the cell content of the hand- and machine-drawn milk likewise show fewer cells in the machine-drawn milk. If these observations stood alone they would have little significance for it is impossible to tell whether these differences were due to the change in the method of milking or to the fact that they were fresh cows. However, the data given on page 143 and in the following section indicate that they are significant and that the smaller number of cells was discharged because of the change in the method of milking.

C. COMPARISON BETWEEN THE CELL CONTENT OF MACHINE-DRAWN AND HAND-DRAWN MILK.

Table XVI gives the averages of the counts in Table II in such a way as to show the differences between hand-milked and machine-

TABLE XVI — COMPARATIVE CELL COUNTS OF MACHINE-DRAWN AND HAND-DRAWN MILK: STATION HERD.

	Number of cells per c.c	Range of Counts.		
		0-500,000.	500,000–1,000,000.	1,000,000 and up.
Count No. 1—Average of 15 machine-drawn samples.	429,000	12	0	3
Average of 8 hand-drawn samples....	122,000	7	1	0
Count No. 2—Average of 15 machine-drawn samples	448,000	12	1	2
Average of 8 hand-drawn samples....	225,000	7	1	0
Count No. 3—Average of 17 machine-drawn samples.	419,000	13	2	2
Average of 8 hand-drawn samples....	292,000	7	1	0
Count No. 4—Average of 15 machine-drawn samples.	516,000	8	3	4
Average of 8 hand-drawn samples....	426,000	5	3	0
Count No. 5—Average of 14 machine-drawn samples.	518,000	8	4	2
Average of 7 hand-drawn samples....	691,000	3	2	2
Count No. 6—Average of 13 machine-drawn samples	274,000	10	3	0
Average of 8 hand-drawn samples....	316,000	5	3	0
Count No. 7—Average of 12 machine-drawn samples.	306,000	9	3	0
Average of 4 hand-drawn samples....	574,000	1	3	0
Count No. 8—Average of 12 machine-drawn samples.	203,000	10	1	1
Average of 5 hand-drawn samples....	691,000	3	0	2
Grand average of 113 machine-drawn samples.......	309,000	82	17	14
Grand average of 56 hand-drawn samples..........	381,000	38	14	4

milked cows. The average of 56 samples of milk drawn by hand is 381,000 cells per cubic centimeter while the average of 113 samples of machine-drawn milk is 309,000 cells per cubic centimeter. Of the 56 hand-drawn samples, 38 gave counts under 500,000 per cubic centimeter, 14 gave counts between 500,000 and 1,000,000 cells per cubic centimeter, and 4 gave counts over 1,000,000 per cubic centimeter while 82 of the cell counts from the machine-drawn milk were under 500,000 per cubic centimeter, 17 were between 500,000 and 1,000,000 per cubic centimeter and 14 were higher than 1,000,000 per cubic centimeter. These results show a somewhat lower cell count for machine-drawn milk than hand-drawn milk which, with the other evidence given which bears on this point, makes it probable that the lower cell count of the machine-drawn milk was due to the method of milking used.

CONCLUSIONS.

The results obtained in these investigations confirm the conclusions formulated by Breed and Stidger[44] in their earlier paper. More definite statements in regard to some points can be made.

Apparently the largest average number of the cells present in milk occurs in colostral milk but equally large numbers of cells occasionally occur in milk drawn at any portion of the lactation period.

Several very high cell counts have been obtained from milk of animals nearing the end of their lactation periods and the evidence here given indicates that such high counts are more common during the latter part of the lactation period than during the height of lactation, but the average cell counts for the latter part of the lactation period do not seem to be markedly higher than the average cell counts of earlier parts of the lactation period. This indicates that the average total number of cells discharged per milking is less during the latter part of the lactation period than during the height of lactation.

There are marked daily variations in the number of cells discharged which do not show a close correlation with any of the suggested causes for such variations.

No constant relation between the number of cells discharged in the foremilk and the number discharged later in the milking process

[44] See footnote 1.

has been found. It is clear that there is an increase in the number of cells in the strippings which may possibly be due to manipulation of the udder as suggested by other investigators. However, it is equally possible that this increase may be due to other factors.

The four quarters of the udder are practically independent of each other, so far as the discharge of the cells is concerned, indicating that the principal cause of the discharge of the cells is something which affects the quarters separately rather than the udder as a whole.

Out of the 122 individual cows whose milk has been examined, 59 have been found to give cell counts under 500,000 per cubic centimeter, 36 gave counts between 500,000 and 1,000,000 per cubic centimeter, and 27 gave counts over 1,000,000 per cubic centimeter. The average cell counts for all of these cows was 868,000 cells per cubic centimeter. The milk of all of these cows was normal in appearance and was sold or used by their owners, who had every reason to suppose that the milk was normal milk.

Changes of a considerable amount in the vacuum used to operate cow milkers were found to be entirely without effect on the cell content of the milk. Several things seem to indicate that the number of cells present in milk drawn by the type of machines here used is somewhat less than that of hand-drawn milk. The fact that all of the cows in the Station herd have been milked by machine during part, at least, of their lifetime is the only apparent explanation of the fact that the milk of this herd showed a much lower average cell content than the milk of other herds. The results obtained in the course of the experiments show clearly that there is no reason for any fear that high vacuums or changes in the vacuum may of themselves cause the excessive discharge of cells or draw blood from the interior of the udder.

The reasons for the discharge of the two kinds of cellular elements are undoubtedly entirely different. The epithelial cells are presumably discharged because they are worn out in the process of the secretion of the milk. Pathological changes in the udder tissues may also cause their discharge from the udder, but under normal conditions, their presence in the milk is probably correlated solely with the processes of secretion.

The reason or reasons for the presence of the leucocytes are not so clear. Many men feel that they are attracted into the milk by the presence of bacteria in the udder, especially by the particular kind of bacteria known as the pus-forming streptococci. This belief has arisen because of a large body of evidence which indicates that the milk of cows suffering from mastitis caused by a streptococcic infection, ordinarily, if not invariably, contains large numbers of cells. But this is not the whole story. It has also been shown that streptococcic infections of the udder occur where there are no pathological symptoms. Are the streptococci present in these cases pathogenic? Does this type of infection likewise cause an increased cell count? How many cows are infected in this way?

It is likewise known that the commonest bacteria present in the udder are micrococci which are so closely related to the pus-forming micrococci (staphylococci) that there are no known cultural tests by which the two can be distinguished. Yet no one has ever attempted to discover whether there is a relationship between the presence of these bacteria and the number of cells discharged. Since such bacteria are present in practically all cows' udders, it is evident that if such a relationship does hold it would be without sanitary significance.

No comprehensive study of the relationship between the number and kinds of cells discharged and the bacterial content of the udder has ever been made which takes these facts into consideration and so it is impossible to make even a reasonable guess as to the probable correctness or incorrectness of the commonly current statement that it is possible to detect infection of the udder by pathogenic streptococci by means of high cell counts. No conclusive results bearing on this point have been secured in the course of the present investigation, although a considerable amount of work was done in an attempt to secure such results.

Enough data were secured however to make it probable that there are other reasons for the discharge of leucocytes in the milk than the presence of bacteria in the udder. These other reasons undoubtedly have to do with the physiological conditions surrounding the process of milk secretion.

No differential counting of these cells has ever been attempted where a satisfactory technique has been used. It is therefore not

surprising that the real reasons for the discharge of the two kinds of cells are so obscure. It is not at all probable that the ratio between the numbers of the two kinds of cells remains constant during the entire lactation period. It remains for future investigation to show what these fluctuations are and to find the cause or causes of them.

BACTERIA OF FROZEN SOIL.*

H. JOEL CONN.

SUMMARY.

1. The number of bacteria in frozen soil is generally larger than in unfrozen soil. This fact was first noticed by the writer in 1910-11 when connected with the Cornell University Agricultural Experiment Station. Recently it has been observed at a different locality and in two other soils, one very different from the first. It is true not only of cropped soil, as shown in the previous work, but also of sod and fallow soil.

2. The increase in number of bacteria after freezing is not due to the increase in soil moisture which usually occurs in winter.

3. The same increase in germ content may take place in potted soil, where there is no possibility that the bacteria are carried up mechanically from lower depths during the process of freezing.

4. The facts noted under the headings 2 and 3 make it very probable that the phenomenon is due to an actual growth of bacteria after the soil is frozen. Its influence on fertility is still an unknown factor.

5. The results given in this bulletin were obtained in a different laboratory and under quite different conditions from those previously reported, thus partly eliminating errors which might have crept in because of peculiarities of technique.

INTRODUCTION.

Until recently considerable attention was given to variations in numbers of bacteria in soil at different seasons and under various conditions; but it is now realized that quantitative work alone is of small significance, and this line of investigation has been largely abandoned. As a result we know very little about the seasonal variation in either kinds or numbers of the bacteria in soil. A study of qualitative seasonal variations has never been undertaken. Samples for quantitative study have often been secured from greenhouse soil; or, if from the field, they have not been taken frequently enough or for a sufficiently long period to yield complete data. The flora of winter soil, in particular, has scarcely been studied.

It was assumed, for a long time, that bacterial activity was almost, if not completely, absent while soil was frozen. This assumption was supported by both theoretical and experimental evidence.

* Reprint of Technical Bulletin No. 35, July.

Theoretically, it had been reasoned that bacteria could not make use of congealed water in their physiological activities. Experimentally, freezing had been shown to prevent the growth and eventually to kill some types of bacteria (as for example *B. typhosus*). Probably these reasons have been largely responsible for the small attention given to the bacterial flora of winter soil.

HISTORICAL.

Remy[1] was among the first to furnish information as to the seasonal variation in numbers of bacteria in field soil. His attention, however, was directed mainly toward the physiological functions of the bacteria, and he did not try to perfect his methods of quantitative study. It is perhaps for this reason that he found no great variation in the numbers, and that his highest count was not over 4,000,000 per gram. None of Remy's samples were taken during the winter.

Hiltner and Störmer,[2] in the course of some experiments designed to show the effects of CS_2-treatment and of fallowing, took samples throughout more than one year. A few of their samples were taken during the winter, but none of them were from soil that had been long frozen. Their highest count was made from soil that had been frozen only a few days before the sample was taken.

Fabricius and von Feilitzen[3] carried out quantitative studies on five soils throughout one vegetative season. They found that the germ content showed a close relationship to soil temperature, so far as they tested the matter; but they examined no winter samples.

Kruger and Heinze,[4] in the course of an investigation of fallow soil, took several samples for bacteriological study during one year, omitting the winter.

Engberding[5] took numerous samples during two seasons of plant growth from fallow and cropped plats, manured and unmanured plats. During most of the year the samples were taken at short intervals; but between October and March only two samples were taken, both of which were from the same plat. These two samples gave moderately high counts, although not so high as some of the others.

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[1] Remy, Th. Bodenbakteriologische Studien. *Centbl. Bakt.* Abt. II, 8:657–662, 699–705, 728–735, 761–769. 1902.

[2] Hiltner, L., and Störmer, K. Studien über die Bakterienflora des Ackerbodens, mit besonderer Berücksichtigung ihres Verhaltens nach einer Behandlung mit Schwefelkohlenstoff und nach Brache. *Kaiserliches Gesundheitsamt, Biol. Abt. Land- u. Forstw.* 3:445–545. 1903.

[3] Fabricius, O., and von Feilitzen, H. Ueber den Gehalt an Bakterien in jungfräulichem und kultiviertem Hochmoorboden auf dem Versuchsfelde des Schwedischen Moorkulturvereins bei Flahult. *Centbl. Bakt.* Abt. II, 14:161–168. 1905.

[4] Kruger, W., and Heinze, B. Untersuchungen über das Wesen der Brache. *Landw. Jahrb.* 36:383–423. 1907.

[5] Engberding, D. Vergleichende Untersuchungen über die Bakterienzahl im Ackerboden in ihrer Abhängigkeit von äusseren Einflussen. *Centbl. Bakt.* Abt. II, 23:569–642. 1909.

In 1910, while associated with the Cornell University Agricultural Experiment Station at Ithaca, N. Y., the writer first called attention to the fact that the number of bacteria in frozen soil is greater than in unfrozen soil.[6] The following winter more data were collected and all were published in a second article[7] appearing in 1911. For the sake of comparison with the results obtained at Geneva during 1912–14, the Ithaca work must be summarized here.

Table I.— Bacterial Counts of Field Soil.
Samples taken at Ithaca, N. Y.

Date.	Bacteria per Gram Dry Soil, in —			
	plat 4b		plat 1b	
	Center.	North end.	Center.	North end.
April 17, 1909	7,000,000	....	18,000,000	....
May 25, 1909	3,300,000	....	10,000,000	....
July 16, 1909	5,000,000	....	4,500,000	....
Sept. 16, 1909	10,000,000	....	*22,000,000	....
Oct. 8, 1909	9,200,000	....	8,000,000	....
Nov. 23, 1909	6,800,000	....	5,750,000	....
Jan. 21, 1910	10,000,000	....	13,000,000	....
Feb. 7, 1910	23,500,000	....	....	....
Feb. 26, 1910	33,000,000	....	27,000,000	....
Mar. 25, 1910	5,700,000	....	6,700,000	....
April 15, 1910	12,000,000	7,000,000	2,500,000	2,000,000
May 28, 1910	7,000,000	....	12,000,000	....
June 15, 1910	14,000,000	....	16,500,000	....
July 2, 1910	13,000,000	....	9,000,000	....
Aug. 20, 1910	8,500,000	....	15,000,000	....
Sept. 14, 1910	9,500,000	7,000,000	13,000,000	7,000,000
Oct. 12, 1910	....	4,000,000	....	6,000,000
Nov. 12, 1910	....	9,500,000	....	5,900,000
Nov. 30, 1910	....	7,000,000	....	7,000,000
Dec. 19, 1910	....	23,000,000	....	17,500,000
Jan. 4, 1911	....	15,500,000	....	20,000,000
Jan. 21, 1911	....	15,000,000	....	10,000,000
Feb. 6, 1911	....	†14,000,000	....	27,000,000
Feb. 22, 1911	....	23,000,000	....	21,000,000
Mar. 3, 1911	....	22,000,000	....	28,000,000
Mar. 29, 1911	....	†16,000,000	....	7,500,000
April 12, 1911	....	14,000,000	....	20,000,000

*This count is probably too high, as little but surface soil was included in the sample.
†These counts are inexact, because of the extremely rapid liquefaction of the plates.

[6] Conn, H. J. Bacteria in Frozen Soil. *Centbl. Bakt.* Abt. II, 28:422–434. 1910.
[7] Conn, H. J. Bacteria of Frozen Soil. II. *Centbl. Bakt.* Abt. II, 32:70–97. 1911.

Two field plats, in Dunkirk clay loam,[8] about twenty feet apart, and both cropped to millet, were sampled nearly thirty times during the two years. The counts are listed in Table I, taken from the second of the two articles already mentioned. These results are also plotted in Graph V. In this graph the relations between the bacterial count, the moisture content of the samples, and the average weekly temperature are shown.

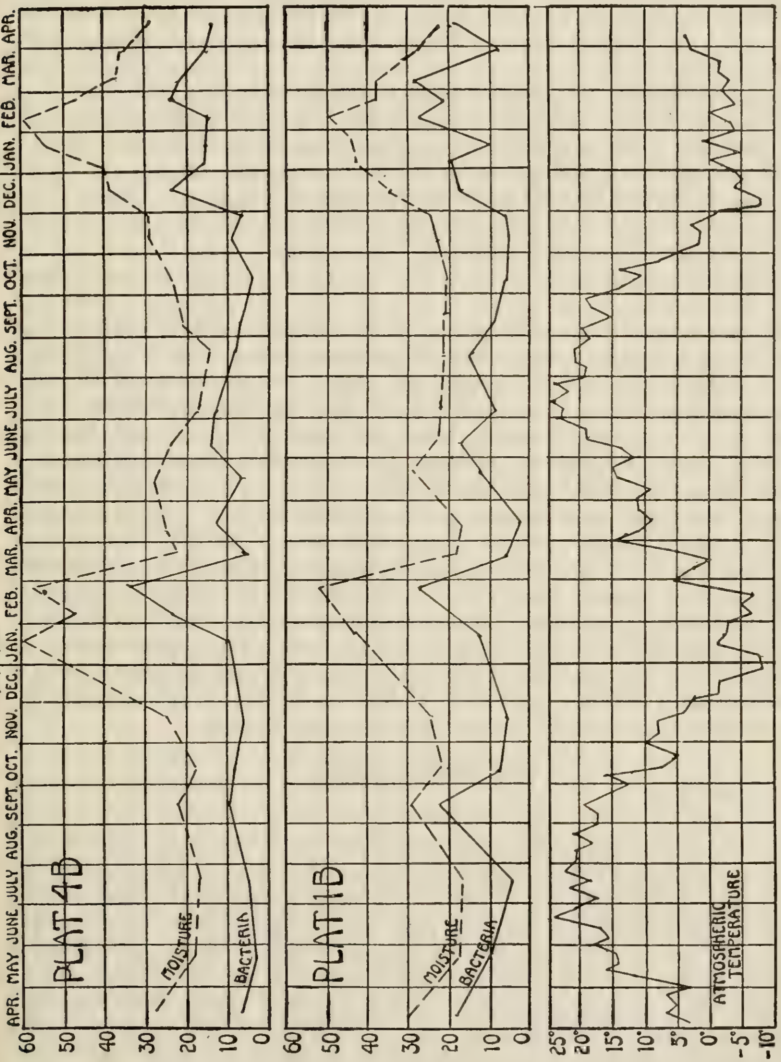
The following points were brought out by these analyses: (*a*) The highest counts were all made while the soil was frozen. Out of seventeen counts made from frozen soil or from soil recently thawed, all were over 10,000,000 and only four under 15,000,000 per gram; while of the forty other samples only fourteen were over 10,000,000 and but five over 15,000,000. The highest count in unfrozen soil (22,000,000) was exceeded by seven of the winter counts. (*b*) During the winter the numbers of bacteria increased while the soil was well frozen, but tended to decrease when it thawed. (*c*) In general, increases and decreases in the numbers of bacteria accompanied rises and falls, respectively, in the moisture content. In January and February, 1911, however, a series of fluctuations occurred which seemed to be closely associated with the freezing and thawing of the soil, but which were plainly independent of changes in moisture content.

This relationship between the number of bacteria and the soil-moisture suggested that the increase in germ content during the winter might be due to the greater moisture content rather than to the difference in temperature. There are two ways in which this may be possible: the added water, even though frozen, may furnish better conditions for bacterial growth; or, provided this increase in moisture is due to a capillary rise of water from lower depths during freezing, it may carry bacteria up with it, thus increasing their numbers in the surface soil without actual multiplication. To test out this point a pot of soil was kept frozen with a constant moisture content of 40 per ct. The experiment was not carried on under the most satisfactory conditions, because warm weather made it necessary to employ a freezing mixture of snow and salt, which resulted in a much lower temperature than that usually found in the field. A further difference from field conditions was caused by the aeration which necessarily results from the ordinary method of filling a pot with soil.

The results of this pot experiment are summarized in Table II. They are inconclusive. An increase in germ content is shown while the soil is frozen; but it is a much smaller increase than that observed under field conditions, and is not followed by a decrease after thawing.

[8] The soil nomenclature of the Bureau of Soils has been used throughout this work. The soils mentioned are described in the Soil Surveys of Ontario and of Tompkins Counties, New York, published by this Bureau. They are all glacial lake-bottom soils; see Fairchild, New York State Museum Bul. 127, pp. 66. 1909.

The experiment was discontinued on April 11, too soon to make it certain that the numbers of bacteria would not, eventually, have returned to their original level.



Graph V.—Bacterial Counts of Field Soil, Made at Ithaca, N. Y.

Numbers of bacteria expressed in millions per gram; moisture content in percentage, dry basis; temperature in degrees Centigrade, average per week.

The multiplication of bacteria in frozen soil, indicated by the analyses made at Ithaca, was so unexpected that some question has

TABLE II.— BACTERIAL COUNTS OF POTTED SOIL.
Samples taken at Ithaca, N. Y.

DATE.	Bacteria per gram dry soil.	Remarks.
1911.		
Jan. 4	5,000,000	Soil standing indoors, moisture 8 per ct.
Jan. 11	10,000,000	Soil indoors, moisture 40 per ct. since Jan. 4.
Jan. 16	12,000,000	Soil indoors, moisture 40 per ct. since Jan. 4.
Jan. 25	7,800,000	Soil frozen since Jan. 16; except on Jan. 21.
Feb. 11	10,700,000	Soil thawed Jan. 26–28; frozen since Jan. 29.
Mar. 20	16,000,000	Frozen artificially since thaw on Feb. 20.
Mar. 27	19,000,000	Still frozen, but not very stiff since Mar. 22.
April 4	21,000,000	Soil thawed since Mar. 27; kept indoors.
April 11	19,000,000	Still thawed; moisture 40 per ct.

been raised as to the correctness of the results. As yet, however, not much work has been done by others to test out the matter. Some unpublished work, carried on under the direction of W. M. Esten, of the Connecticut Agricultural College, has shown the germ content of soils to increase after freezing. Brown and Smith[9] recently made a study of bacteria in frozen soil, obtaining quantitative data from eight samples of soil. All of their counts are lower than those which were found in the present work, a fact which can be at least partially explained by their use of a different culture medium and of a shorter period (three days) of incubation. Although some of their counts from frozen soil were lower than others made before freezing, the highest count of all was from soil that had been the longest frozen. This fact is particularly interesting when we consider that the bacteria which show the most striking increase in numbers after freezing grow very slowly on the plates and are largely overlooked when a short period of incubation is used.

PRESENT WORK.

PLAN.

This work was planned to throw light upon the same two questions which it had been hoped to answer by the pot experiment in the earlier work (see page 182). The first question is whether the increase in numbers of bacteria may not be due merely to a rise of the organisms from lower depths, brought about by ascending currents of soil-water. The second is whether it is the low temperature or the high moisture content of winter soil that favors the bacteria. To answer these questions, soil was allowed to freeze in pots, so that its moisture content could be controlled and no water could rise

[9] Brown, P. E., and Smith, R. E. Bacterial Activities in Frozen Soils. Iowa Agr. Exp. Station, Research Bul. 4:158-184. 1912.

from below. Both aerated and unaerated soil were used in these pots, the unaerated soil having been obtained by digging a block from the field and transferring it directly to a pot. It was hoped by this means to see whether the failure of the previous pot experiment to show an appreciable increase in germ content could have been due to the unnatural aerated condition of the soil.

Parallel to these pot experiments, tests were made of the same soil (Dunkirk silty clay loam) in the field. In these tests, also, both aerated and unaerated soils were used. The unaerated soil was merely an undisturbed field plat that had been kept fallow since 1911, the upper two or three inches having been cultivated after every rain to preserve a dust mulch. There were two portions of aerated soil, one aerated in November, 1911, the other in November, 1913. The former portion, after aeration, was replaced within a large tile such as is used for sewer pipe, two feet in diameter and two feet long, buried in the field with only its flange above ground, and the soil so placed within it that the subsoil was below and the surface soil above in a layer of the same depth as occurs naturally in the field. This soil, like that of the unaerated plat, had been kept fallow since 1911. The second portion, aerated in 1913, consisted of surface soil alone and was replaced within a smaller cylinder, six inches deep and six inches in diameter, likewise sunk in the field.

A third series of tests was made in an entirely different soil, Dunkirk fine sand. Two spots were chosen, about fifty feet apart. One was in sod; the other at the edge of a strawberry field, in a spot that was practically free from any vegetation, either because it had been frequently cultivated or because of the poor quality of the soil. These tests were made to see whether the bacteria increase in numbers in a frozen sand as well as in a clay loam. The samples examined were unfortunately few in number.

METHODS.

The methods employed have been kept as nearly as possible the same as those used in the earlier work. Soil samples were regularly taken by boring to about six inches, although some of the winter samples were taken to a slightly less depth because of the difficulty in boring through frozen soil. The soil thus obtained was thoroughly mixed, by sifting, if dry enough, or by stirring, if muddy. A 0.5-gram portion of this sample was finally selected and shaken for two minutes with 100 cubic centimeters of sterile water in a stoppered flask. After this shaking, the suspension was further diluted, care being taken to keep the contents of the flask in motion when any of the suspension was withdrawn. One cubic centimeter of the proper dilution was finally added to each plate. The dilutions used were 1:100,000 and 1:200,000 or 1:200,000 and 1:500,000. Three or four plates of each dilution were always made.

Various media were tried in this work; but none ordinarily gave higher counts than the soil-extract gelatin described in the earlier articles. As a result, the figures chosen for publication are the counts obtained upon that medium and are comparable with those of the previous work. The composition of the medium is:

Gelatin	12 per ct.
Soil-extract	20 per ct.
Dextrose	0.1 per ct.

Reaction adjusted to 0.5 per ct. normal acid to phenolphthalein.

In order to obtain the soil-extract, soil was heated for an hour at one atmosphere pressure, then mixed with an equal weight of cold water, allowed to stand over night, then boiled for half an hour and filtered.

The plates were incubated at a temperature of 17.5° to 18° C. for seven days before counting. In averaging the counts, consideration was taken of the fact that when over one hundred colonies appeared on a plate, overcrowding generally prevented the development of some of the bacteria. In such cases the greater dilution almost invariably gave the higher count, and the lower dilution was disregarded. Occasionally, however, the higher count was obtained from the lower dilution even though there were over one hundred colonies per plate, and then the counts of both sets of plates were averaged. If, on the other hand, there were less than one hundred colonies per plate, the difference between the counts obtained from the two dilutions was likely to be less than between those from parallel plates of the same dilution; so in this case the counts obtained from all the plates were averaged. In choosing the dilutions an attempt was made to obtain between fifty and one hundred colonies per plate in one or the other of the dilutions employed.

RESULTS OF POT WORK.

This work was planned, as already mentioned, for two purposes: to control soil moisture and to prevent the rise of bacteria from lower depths. In 1912 two pots, one aerated and the other unaerated, were prepared and tested occasionally during the following winter. The soil was frozen for such short periods, however, that the experiment was unsatisfactory, and it was repeated a second year, with four pots instead of two. The soil in two of these pots was aerated, in the other two unaerated. The two pots prepared the first winter were left uncovered, so that their moisture content rose and fell much the same as the field soil. During the second winter the four pots were kept covered, and their moisture content remained constant until the thaw in March, when melting snow managed to get beneath the covers.

The results of this work are given in Tables III and IV; while the results for 1913–14 are also plotted in Graphs VI and VII. The

same graphs and tables show the moisture content of the samples (referred to dry basis). The atmospheric temperature (also shown in Table VII) is plotted in the two graphs. The atmospheric temperature was obtained by averaging the daily mean temperature for each week.

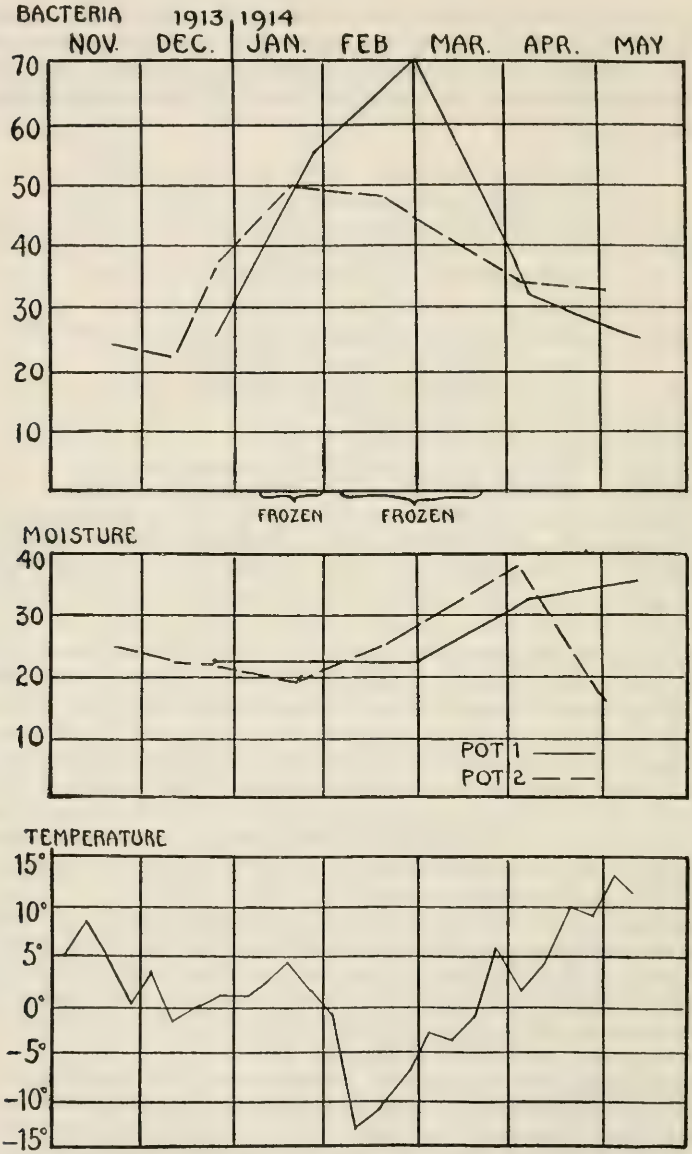
Table III.— Bacterial Counts of Potted Soil.
Samples taken at Geneva, N. Y., 1912–13.

Date.	Aerated Soil.		Unaerated Soil.		Remarks.
	Moisture content	Bacteria per gram dry soil.	Moisture content.	Bacteria per gram dry soil.	
	Per ct.		*Per ct.*		
Nov. 16, 1912	19.5	37,000,000	19.5	25,000,000	Unfrozen.
Dec. 3, 1912	23	50,000,000	23.5	37,000,000	Unfrozen.
Feb. 11, 1913	18.5	44,000,000	19	27,500,000	Frozen 10 days.
Feb. 19, 1913	34	60,000,000	30	57,000,000	Frozen 18 days.
April 15, 1913	18.5	48,000,000	18	28,000,000	Thawed since Feb. 21.

The most significant samples taken in 1912–13 are those of February 19th, which were from well-frozen soil. The analyses show a decided increase in germ content over all counts from the soil while unfrozen. The only other samples of frozen soil taken were on February 11th, ten days after the freeze and apparently before the bacteria had begun to increase in numbers. The results, therefore, bear out previous work, but depend upon too few determinations to be conclusive. It is interesting to notice that increases and decreases in numbers of bacteria throughout the experiment accompany rises and falls in the moisture content.

The results of the work in 1913–14 are more conclusive. During this year eight samples were taken of soil that had been frozen at least two weeks. Of these, all but one gave strikingly higher counts than those obtained in the fall or spring. The results plainly cannot be ascribed to changes in moisture content, for no increase in the latter occurred until the final thaw in March.

Considering both years' work together, we find that nine out of twelve samples of frozen soil were abnormally high in germ content. Of the three that were no higher than normal, two were taken so soon after the freeze that the bacteria probably had not had time to increase in numbers. The chief significance of this experiment lies in the fact that the possibility of bacteria rising from lower depths during the process of freezing was excluded, thus showing



Graph VI.—Bacterial Counts in Aerated Soil, Pot Experiment, 1913-14.

Bacteria in millions per gram; moisture content in percentage, dry basis; temperature in degrees Centigrade, average per week.

Table IV.— Bacterial Counts of Potted Soil.

Samples taken at Geneva, N. Y., 1913–14.

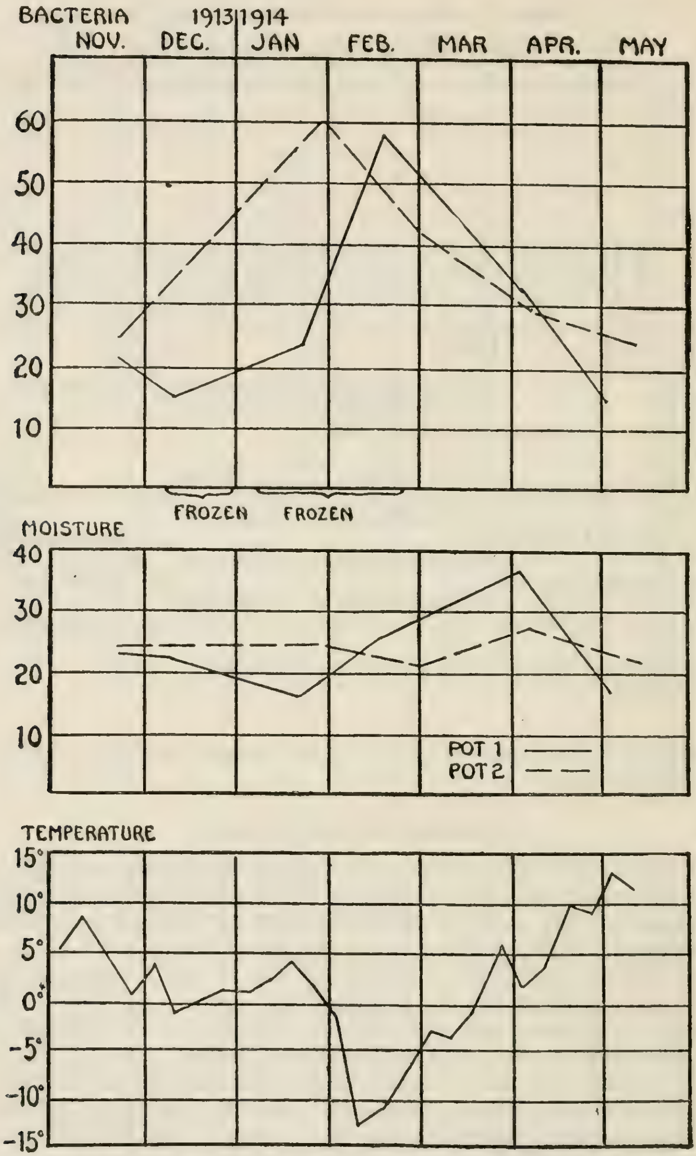
Date.	Aerated Soil.				Unaerated Soil.				Length of time frozen.
	pot 1.		pot 2.		pot 1.		pot 2.		
	Moisture content.	Bacteria per gram dry soil.	Moisture content.	Bacteria per gram dry soil.	Moisture content.	Bacteria per gram dry soil.	Moisture content.	Bacteria per gram dry soil.	
	Per ct.		*Per ct.*		*Per ct.*		*Per ct.*		
1913.									
Nov. 24	....	....	25	24,000,000	22	21,000,000	23	24,000,000	*
Dec. 11	....	....	22	22,000,000	21.5	16,000,000	....	....	3 days.
Dec. 26	22	26,000,000	22	37,000,000	....	....	....	....	*
1914.									
Jan. 24	....	....	19.5	50,000,000	17	24,000,000	....	....	15 days.
Jan. 28	22	56,000,000	....	....	....	....	24.5	60,000,000	19 days.
Feb. 20	....	....	24.5	49,000,000	26.5	58,000,000	....	....	15 days.
Feb. 28	22	71,000,000	....	....	....	....	21	42,000,000	23 days.
April 3	....	....	38.5	34,000,000	37	32,000,000	....	....	*
April 7	33.5	30,500,000	....	....	....	....	27	29,500,000	*
May 2	....	....	18.5	32,000,000	18	16,000,000	....	....	*
May 14	36	26,500,000	....	....	....	....	22	25,000,000	*

* Unfrozen.

conclusively that the increase in germ content could not have been due to this cause.

RESULTS OF FIELD WORK.

Dunkirk silty clay loam.— The analyses of this soil (the same type as used in the pot experiments) were made during three successive winters; but only the results secured in 1913–14 have sufficient meaning to justify publication in detail. During 1911–12 no constant temperature was available for use in the incubation of the plates, a condition which rendered the results unreliable. Seven samples of frozen soil were taken during that winter, of which two showed between thirty-five and forty million bacteria per gram, counts which are much higher than ordinarily obtained from this soil when in an unfrozen condition. In the winter of 1912–13 the soil was unfrozen except for two short periods, and only six samples were taken, of which only two were obtained as much as two weeks after a freeze. One of these two counts reached the striking figure of 55,000,000 bacteria per gram.



GRAPH VII.—BACTERIAL COUNTS IN UNAERATED SOIL, POT EXPERIMENT, 1913-14.

Bacteria in millions per gram; moisture content in percentage, dry basis; temperature in degrees Centigrade, average per week.

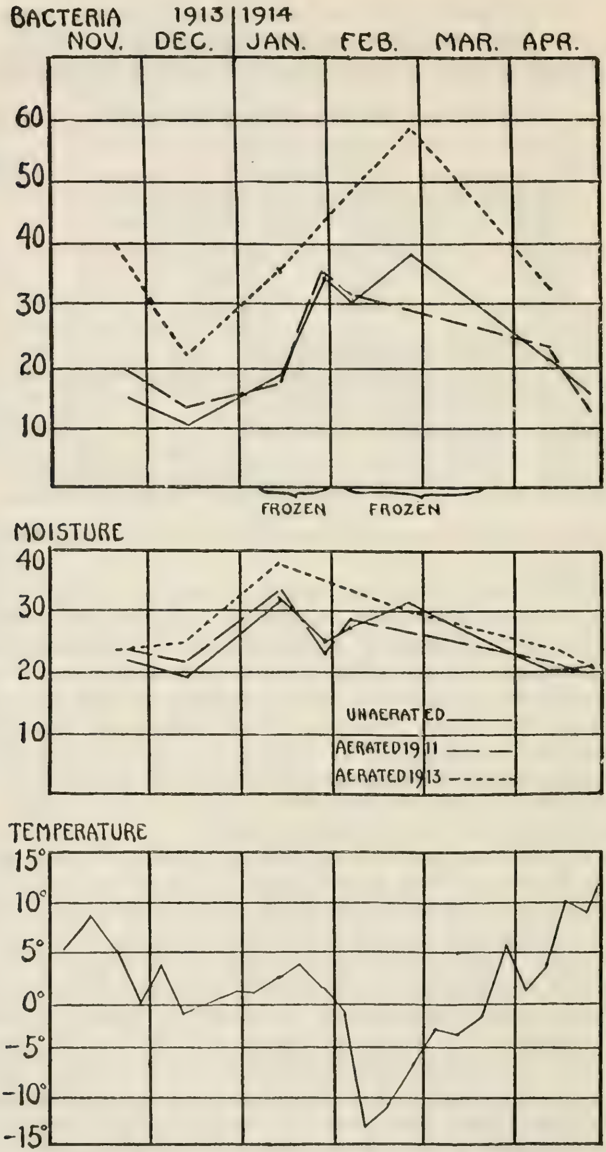
Table V.— Bacterial Counts of Field Soil.

Samples of Dunkirk silty clay loam.

Date.	Unaerated.		Aerated, 1911.		Aerated, 1913.		Remarks.
	Moisture content.	Bacteria per gram dry soil.	Moisture content.	Bacteria per gram dry soil.	Moisture content.	Bacteria per gram dry soil.	
	Per ct.		*Per ct.*		*Per ct.*		
Nov. 24, 1913	....	....	....	....	23.5	40,000,000	Unfrozen.
Nov. 26, 1913	21.5	16,000,000	23.5	20,000,000	....	....	Unfrozen.
Dec. 15, 1913	19.5	11,000,000	22.5	13,500,000	25.5	22,000,000	Unfrozen.
Jan. 16, 1914	31	19,000,000	33.5	18,000,000	37.5	35,000,000	Frozen 9 days.
Jan. 30, 1914	24.5	33,000,000	23	34,000,000	....	....	Thawed 1 day.
Feb. 7, 1914	27.5	30,000,000	28	31,000,000	....	....	Partially frozen.
Feb. 26, 1914	31	38,000,000	....	....	30	59,000,000	Frozen 21 days.
April 15, 1914	20	21,000,000	20.5	23,000,000	23.5	32,000,000	Unfrozen.
April 29, 1914	20.5	16,000,000	20	13,000,000	20.5	22,000,000	Unfrozen.

The results for 1913–14 are worth giving in detail. During this year the weather was more favorable, samples were taken more frequently, and laboratory conditions were well controlled. As already mentioned, three series of tests were made: one from undisturbed field soil, fallow since 1911; one from aerated soil replaced in the field in November, 1911, and held fallow; and the third from soil aerated in November, 1913, and then replaced in the field. The results of the analyses are given in Table V. In Graph VIII they are plotted, together with the moisture content of the samples and the average atmospheric temperature per week.

Seven of these counts were made from frozen soil, and two others from soil that had been thawed only twenty-four hours. All but two of these nine counts were above thirty million; and these two were taken only nine days after the first freeze of the winter. None of the counts made from unfrozen soil were above thirty million except two, both from the soil aerated in 1913, one on November 24th, immediately after aeration, and the other on April 15th, when this soil was found to be unusually moist and to have a musty odor because of a heavy piece of burlap that had been accidentally allowed to lie over it since the thaw. These exceptions occurred under such abnormal conditions that they are easily understood and do not affect the conclusion that the number of bacteria usually found in frozen soil is greater than in the same soil under ordinary summer conditions.



GRAPH VIII.—BACTERIAL COUNTS FROM FIELD SOIL, DUNKIRK SILTY CLAY LOAM.

Bacteria in millions per gram; moisture content in percentage, dry basis; temperature in degrees Centigrade, average per week.

Dunkirk fine sand.— The results of several tests in Dunkirk fine sand are given in Table VI. Three of the four samples of this sandy soil taken while frozen show distinct evidence of an increase in the germ content similar to that occurring in clay. The one sample from the cultivated portion taken on February 27th, shows the extremely high count of 95,000,000 per gram. This is a very interesting fact

Table VI.— Bacterial Counts of Field Soil.
Samples of Dunkirk fine sand.

Date.	Sod.		Cultivated Soil.		Remarks.
	Moisture content.	Bacteria per gram dry soil.	Moisture content.	Bacteria per gram dry soil.	
	Per ct.				
April 29, 1913	16	10,000,000	......	....	Unfrozen.
Nov. 18, 1913	11	8,000,000	9.5	9,000,000	Unfrozen.
Dec. 1, 1913	10	8,800,000	8	7,500,000	Unfrozen.
Feb. 27, 1914	34.5	57,000,000	29	95,000,000	Frozen 22 days.
Mar. 14, 1914	22	8,000,000	33	26,000,000	Frozen 37 days.
May 9, 1914	10	11,000,000	11	9,000,000	Thawed 2 months.

when the ordinary low count in this soil under normal conditions is noticed. It is impossible to tell, however, whether such a great increase in numbers is usual in this soil or is an isolated case to be found only in this one sample.

DISCUSSION.

In general, the results here obtained verify the previous results but do not explain them. They show that bacteria apparently increase in numbers in frozen soil when all possibility of their being carried up from lower depths is excluded. This increase seems to depend on the low temperature or upon freezing rather than upon an increase in soil moisture.

There is still some possibility, however, that the increase may not be an actual multiplication. Bacteria probably occur in the soil, to some extent, in masses that are too firmly bound together to be broken up by the shaking given the soil when it is diluted for plating. In such a case each colony developing on the plates represents either an isolated organism or an aggregate of two or more bacteria. It is entirely possible that the freezing may break up these masses and thus increase the plate count without adding to the actual number

of bacteria present in the soil. It is very difficult to obtain any evidence bearing on this point. The only evidence so far obtained is the fact that bacteria have generally been found to reach their highest numbers two or three weeks after freezing, while if the increase were actually due to a breaking-up of the bacterial masses in the soil, the process ought to stop as soon as the soil is completely frozen. Moreover, if this be the true explanation, it is extremely unlikely that the count immediately after the thaw would be so nearly the same as it was before the freeze.

If this increase in germ content is due to an actual multiplication, the results seem to imply, on first thought, that soil organisms are able to use congealed water in their physiological activities. The soil-temperature, however, a few inches below the surface is seldom much below freezing in this climate, and the denser portions of the soil solution may never freeze. In these unfrozen portions, the growth of certain kinds of bacteria may be favored. This possibility was mentioned in the writer's first publication on the subject (1910).[10] Later it was further discussed by Brown and Smith.[11]

That certain bacteria can multiply at temperatures as low as this has been recognized for some time, cold storage conditions having been found insufficient to prevent all bacterial growth. It is strange, however, that low temperatures should seem to be more favorable than higher ones for the soil flora. The optimum temperature for nearly all of the soil bacteria which the writer has isolated has proved to be between 20° and 30° C. These bacteria show greater differences, however, in respect to their minimum temperature of growth. This fact is the basis of the theory already advanced to explain the increase in numbers while the soil is frozen. If we assume that there are two hostile classes of bacteria in the soil, one able to grow at temperatures below freezing, the other with its minimum temperature considerably higher, it is plain that sufficiently low temperatures would suppress one class and allow the other to increase with more than normal rapidity, even though these same organisms prefer higher temperatures in pure culture.

This theory ought not to be difficult to prove. If a distinct difference could be shown between the kinds of bacteria in frozen soil and those found when unfrozen, it would make this explanation seem extremely probable. No such difference, however, has been found. As the writer has elsewhere remarked,[12] there is a surprising similarity between the predominating bacteria found in different soils and in the same soil at different seasons. It is nevertheless possible, considering the crudity of present methods for classifying bacteria, that differences exist which have not been detected.

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[10] See footnote 6.

[11] See footnote 11.

[12] Conn, H. J. The Distribution of Bacteria in Various Soil Types. *Journ. Amer. Soc. Agron.* 5:218–221. 1913.

Table VII.— Atmospheric Temperature, 1912–14.

1912.		Average temperature, degrees Centigrade.	1913		Average temperature, degrees Centigrade.
November	1– 8	8.5	August	1– 8	21.5
	9–15	9		9–15	23.5
	16–23	5.5		16–23	20
	24–30	0.5		24–31	19
December	1– 8	4	September	1– 8	24
	9–15	—1		9–15	24.5
	16–23	0		16–23	18
	24–31	1		24–30	16
1913.			October	1– 8	15
January	1– 8	1		9–15	13.5
	9–15	—2		16–23	11.5
	16–23	4		24–31	8.5
	24–31	1.5	November	1– 8	5
February	1– 7	—8		9–15	8.5
	8–14	—7		16–23	5
	15–21	1		24–30	0.5
	22–28	—4	December	1– 8	4
March	1– 8	—6		9–15	—1
	9–15	6.5		16–23	0
	16–23	5		24–31	1
	24–31	5.5	1914.		
April	1– 8	6	January	1– 8	1
	9–15	9		9–15	2.5
	16–23	10		16–23	4
	24–30	14.5		24–31	1.5
May	1– 8	18	February	1– 7	—1
	9–15	9.5		8–14	—13
	16–23	14.5		15–21	—10.5
	24–31	13.5		22–28	—7
June	1– 8	17	March	1– 8	—3
	9–15	18		9–15	—3.5
	16–23	19.5		16–23	—1
	24–30	23.5		24–31	6
July	1– 8	24	April	1– 8	1.5
	9–15	19.5		9–15	4
	16–23	21.5		16–23	10
	24–31	24		24–30	9.5
			May	1– 8	13.5
				9–15	12

Another explanation, offered by Russell,[13] is quite similar to this, but assumes that the hostile organisms suppressed by the low temperatures are not bacteria, but larger organisms, probably Protozoa. Russell, indeed, thinks it probable that the bacteria in soil are normally held in check by these protozoa; and that only after soil has been heated, frozen, dried, or treated with antiseptics, can the bacteria multiply to the greatest possible numbers. This theory is

[13] Russell, E. J. The Effect of Partial Sterilization of Soil on the Production of Plant Food. *Jour. Agr. Sci.* **5**:152–221. 1913.

likewise unsupported by any direct evidence. It is a particularly hard theory either to prove or to disprove because of the difficulty in determining whether protozoa live in the soil in their active state.

If Russell's theory is correct, the increase in germ content which takes place in frozen soil is closely related to that which has been shown to occur in partially sterilized soil. Until recently the best supported explanation of the latter phenomenon was that the treatment necessary to effect partial sterilization disturbed the equilibrium of the soil bacteria and as a result allowed certain kinds to multiply abnormally. Now that Russell has proposed his protozoan theory, opinion is divided. Whichever explanation is the more probable, it is possible that the rapid increase in numbers of bacteria in partially sterilized soil and their multiplication in frozen soil may be due to similar causes. The improved crop-yields in the former case raise the question as to whether the increased germ content in the latter case has any practical importance. If the bacteria that multiply during the winter are favorable to plant growth, a cold winter may have a more beneficial effect on following crops than a warm one. This question leads into the unsolved problem of seasonal variation among soil bacteria. It shows the necessity of knowing what kinds of bacteria predominate at different seasons, and what influence each kind has upon plants.

CULTURE MEDIA FOR USE IN THE PLATE METHOD OF COUNTING SOIL BACTERIA.*

H. JOEL CONN.

SUMMARY.

1. Two new culture media have been tested to determine their merits when employed in the plate method of counting soil bacteria. One is a soil-extract gelatin, the other an agar medium containing no organic matter except the agar, dextrose and sodium asparaginate.

2. The soil-extract gelatin is recommended primarily for use when the plate method is employed as a preliminary procedure in a qualitative study of soil bacteria. Its advantages are that the colonies produced upon it by different types of bacteria are fairly distinct in appearance, and rather more of the soil bacteria produce colonies upon it than upon any other medium investigated. Its disadvantages are such that they do not render it less satisfactory for qualitative purposes although they might make its use inadvisable in quantitative work.

3. The chief advantage of the asparaginate agar is that it contains no substance of indefinite composition except the agar itself. This ought to allow comparable results to be obtained by its use, even though the work be done by different men and in different laboratories. It is therefore especially adapted to quantitative work.

4. Four other media have been compared with these. They are those recommended for use in soil bacteriological studies by Fischer, by Lipman and Brown, by Temple, and by Brown. For qualitative purposes they are all distinctly inferior to gelatin. For quantitative work they are undesirable because they contain substances of indefinite chemical composition. It has been found that no one of the five agar media has a distinct advantage over any of the others in the matter of the total counts obtained by their use.

INTRODUCTION.

Ever since the bacteriology of soil was first studied, one of the most common lines of investigation has been to determine the number of bacteria living in different soils. It was thought at first that the number of bacteria present was proportional to the productivity of the soil. Investigation, however, soon proved that the rule held only in a very general way, and that exceptions were

* Reprint of Technical Bulletin No. 38, November.

extremely numerous. Quantitative work, therefore, fell more and more into disfavor until in 1902 Remy[1] stated that mere determinations of the number of bacteria were of no use. Remy realized the importance of knowing not only the numbers of bacteria, but also the kinds present and their functions. He considered a complete study of this sort, however, too colossal a task to be undertaken. As a practical substitute for a complete qualitative study, Remy suggested a method of obtaining a qualitative knowledge of soil bacteria without counting them or separating the different kinds from each other. This was accomplished by measuring the chemical changes which the total flora of any soil was capable of producing when inoculated into special liquid media. Bacteriological methods, today, have improved to such an extent that it may soon be possible to make a more complete study of soil bacteria, including determinations of the number of each kind of bacteria present as well as the total number, and also of the functions of the various bacteria. Quantitative as well as qualitative methods, however, must be perfected before a complete study of this sort becomes possible.

The usual method employed in quantitative work has been to count the colonies developing upon a plate of nutrient gelatin or agar inoculated with a small amount of soil infusion of definitely known dilution. It is known that the composition of the nutrient gelatin or agar has considerable influence upon the results, but the best possible composition has not yet been determined. The present investigation is a study of the relative merits of various culture media for this purpose. The results are to be considered as merely preliminary; but they are published as an aid to others who are striving after satisfactory media for soil bacteriological work.

USES AND LIMITATIONS OF THE PLATE METHOD.

The weaknesses of the plate method of counting bacteria are too well known to need much discussion. It is an indirect method, for by its use the bacteria are counted only by means of the colonies they produce on the plates. In interpreting the colony count as though it were a count of the bacteria themselves, it has to be assumed that every bacterium mixed with the culture medium develops into a macroscopic colony, an assumption that is not justified unless the composition of the medium, the temperature of incubation, and the length of time allowed to elapse before counting are such as to permit the growth of every kind of organism present, and unless the bacteria are so well separated from each other that no colony represents more than a single individual. These conditions have never been fully met, and probably never can be.

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[1] Remy, Th. Bodenbakteriologische Studien. *Centbl. Bakt.*, **Abt. II**, 8:657–662, 699–705, 728–735, 761–769. 1902.

A still greater weakness results from the fact that the culture media in general use are such that there is no means of being sure in any case to what extent these conditions have been met. The fault of the ordinary culture media is that they contain materials of indefinite composition, different lots of which undoubtedly vary sufficiently in composition so that conditions are at times more favorable for bacterial growth than at others. The result is that the counts obtained by different workers, or by the same worker when using different batches of media, may vary greatly, even though there be no variation in the actual number of bacteria present.

The fact that the plate method gives incomplete counts when applied to soil has been illustrated by comparing it with the only other method that has been proposed for counting soil bacteria. Hiltner and Störmer[2] suggested that liquid instead of solid media be used for making quantitative determinations. They recommended the use of four different liquid media in making each test, each medium adapted to the growth of some particular group of soil bacteria. Their method was to inoculate each medium with small portions of soil infusion of many different dilutions, some of them so dilute as to cause no reaction to take place in the medium into which they were introduced. Having determined how great a dilution was necessary in inoculating each medium before tubes could be obtained in which bacteria adapted to that medium were lacking, a simple calculation sufficed to show the approximate number of each of these groups present in the soil investigated. This dilution method, according to Löhnis,[3] gives higher counts than the plate method, a fact which suggests that many bacteria are overlooked when the latter method is used.

In spite of this well-known weakness of the plate method, it is in common use today, while Hiltner and Störmer's method is rarely employed. This is partially to be explained by the relative convenience of the two methods. Hiltner and Störmer's method is cumbersome, while poured plates furnish a simple and convenient means of testing several samples in a comparatively short time. A second advantage of the plate method is that it is possible to isolate pure cultures of the various bacteria from the colonies that develop on the plates. The study of these pure cultures gives a more thorough qualitative knowledge of the soil flora than can be obtained by Hiltner and Störmer's method.

This second advantage of the plate method must be made even greater before the procedure becomes of the greatest possible value

[2] Hiltner, L., and Störmer, K. Studien über die Bakterienflora des Ackerbodens, mit besonderer Berücksichtigung ihres Verhaltens nach einer Behandlung mit Schwefelkohlenstoff und nach Brache. *Kaiserliches Gesundheitsamt. Biol. Abt. Land. u. Forstw.*, 3:445–545, 1903.

[3] Löhnis, F. Zur. Methodik der bakteriologischen Bodenuntersuchung II. *Centbl. Bakt.* Abt. II, 14:1–9, 1905.

in qualitative work. Qualitative bacteriological analysis depends upon the ease with which the colonies of different types of bacteria can be distinguished from each other. The differences in appearance of the colonies result from certain peculiarities possessed by the bacteria themselves, such as their nutritive requirements or methods of growth. The extent to which these peculiarities are impressed upon the colonies depends upon the conditions of growth furnished by the medium. Unfortunately many of the media in use for the plate method are not favorable to the development of these differences in appearance.

CHARACTERISTICS OF A SATISFACTORY CULTURE MEDIUM FOR THE PLATE METHOD

These limitations of the plate method cannot be entirely overcome; but the technique may be made more serviceable by using a more satisfactory medium. There are at least three important requirements that must be met by any medium before it can be considered perfectly satisfactory for soil work: (1) It must allow the growth of the greatest possible number of soil bacteria. (2) The colonies produced upon it by different types of bacteria must be as distinct as possible in appearance. This requirement, however, need not be met if mere quantitative results are desired. (3) It must be what bacteriologists often term a "synthetic" medium; i. e., of definite chemical composition. This requirement applies especially to quantitative work.

As the plate method serves at least two distinctly different purposes, it may be possible to use two different media, neither of which meets all three requirements. One medium, designed primarily for qualitative work, should fulfill the first and second requirements; the other, intended for quantitative purposes only, should fulfill the first and third.

In the present investigation an agar medium and a gelatin medium have been studied. Both have been tested as to their ability to meet the first of these three requirements. The former has been tested because, like all other gelatin media, it allows good distinctions between the colonies of many kinds of bacteria, and thus fulfills, in part at least, the second requirement. The latter was tested because it contains no material of indefinite chemical composition except the agar itself, and thus nearly fulfills the third requirement.

REVIEW OF LITERATURE.

Previous work along this line has had but one main object in view — that of obtaining a medium allowing the greatest possible number of soil bacteria to produce colonies. The other two requirements just mentioned have been largely overlooked. Some investigators have used the ordinary media of general bacteriological work,

such as beef-extract-peptone gelatin, as used by Hiltner and Störmer,[4] or Heyden agar as used by Engberding.[5] None of these were very satisfactory and it was soon concluded that special media must be used in soil work. The simplest modification (e. g. that of Hoffman[6]) differed from the ordinary beef-extract-peptone formulæ only in the substitution of soil-extract for pure water. A slight improvement was claimed for this modified formula, but it has not been generally regarded as sufficient to warrant its continued use.

The recent modifications have all been of a different sort. The best results have been obtained on media low in organic matter. The low organic content of these media undoubtedly holds in check certain rapidly growing organisms that would otherwise prevent the growth of the more numerous but more slowly growing bacteria. Fisher[7] in 1909 described several media of this nature. Early in the following year[8] Fischer recommended another medium, still simpler in composition, which allowed even more soil bacteria to produce colonies. This last medium was an agar to which nothing was added but soil-extract (prepared by extracting with a 0.1 per ct. solution of Na_2CO_3) and potassium phosphate. The advantage of reducing the amount of organic matter was discovered contemporaneously by Lipman and Brown[9] who recommended an agar which contained no nitrogen beyond that furnished in 0.05 gram of peptone per litre. In 1911 Temple[10] recommended a culture medium for soil work which was also low in organic content, although it contained one gram of peptone per litre. Temple states that he could obtain better results with this medium than with Lipman and Brown's formula. In 1913 Brown[11] published a modification of Lipman and Brown's formula, replacing the .05 gram of peptone with one gram of albumin. (For the complete formulæ of the last four media see Table I.) Brown gives the results of six comparative tests that

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[4] See footnote 2.

[5] Engberding, D. Vergleichende Untersuchungen über die Bakterienzahl im Ackerboden in ihrer Abhängigkeit von äusseren Einflussen. *Centbl. Bakt.* Abt. II, 23:569–642, 1909.

[6] Hoffman, C. Relation of Soil Bacteria to Nitrogenous Decomposition. Wis. Agr. Exp. Sta., 23 Ann. Rpt., pp. 120–134, 1906.

[7] Fischer, H. Bakteriologisch-chemische Untersuchungen. Bakteriologischer Teil. *Landw. Jahrb.* 38:355–364, 1909.

[8] Fischer, H. Zur. Methodik der Bakterienzählung. *Cenbtl. Bakt.*, Abt. II, 25:457–459,1910. Although similar soil-extract media have been used by other bacteriologists, the directions given by Fischer for preparing this medium are so explicit that it is denoted in the present publication as Fischer's soil-extract agar.

[9] Lipman, J. G., and Brown, P. E. Media for the Quantitative Estimation of Soil Bacteria. *Centbl. Bakt.*, Abt. II, 25:447–454, 1910.

[10] Temple, J. C. The Influence of Stall Manure upon the Bacterial Flora of Soil. *Centbl. Bakt.*, Abt. II, 34:206–223, 1911. Also Ga. Agr. Exp. Sta., Bul. 95:1–34, 1911. (See p. 9 of the latter reference.)

[11] Brown, P. E. Media for the Quantitative Determination of Bacteria in Soils. *Centbl. Bakt.* Abt. II, 38:497–506, 1913. Also Ia. Agr. Exp. Sta. Research Bul. 11:396–407, 1913.

show a slight superiority of this albumin agar both over Lipman and Brown's earlier medium and over Temple's agar.[12] Each of these media has been recommended by a different investigator, and, beyond the tests made by Brown, no comparison between them seems to have been published.

The little weight which the authors of these media have attached to the matter of distinctions in appearance between different kinds of colonies is shown by the fact that they have scarcely ever recommended the use of gelatin media. A few investigators, it is true, such as Hiltner and Störmer[13] used the ordinary beef-extract-peptone gelatin. Hoffman[14] similarly used a beef-extract-peptone gelatin with soil-extract. Fischer[15] mentioned rather casually the use of a gelatin medium containing nothing but gelatin, soil-extract, and 1 per ct. of dextrose, but does not recommend its use on account of the low and irregular counts obtained upon it. A modification of Fischer's formula (containing 0.1 per ct. instead of 1 per ct. dextrose) has been used by the writer with very good results. The use of this last mentioned formula has been referred to already in several publications;[16] but no counts have yet been given to show how this medium compares with others. It is the gelatin medium to which particular attention is to be given in the present paper.

The use of soil-extract, peptone or some other substance of unknown chemical formula in all of these media shows how little stress has been laid upon the importance of having culture media of definite chemical composition. Lipman and Brown's medium alone is fairly satisfactory in this respect. Its authors, indeed, speak of it as a "synthetic" agar, in spite of the fact that it con-

[13] The following is a summary of the six tests, taken from Brown's tables (loc. cit.):

TEST	Lipman and Brown's agar.	Brown's albumin agar.	Temple's peptone agar.
1	5,478,000	6,735,000	5,791,000
2	5,200,000	7,775,000	5,225,000
3	4,866,000	7,113,000	5,066,000
4	4,688,000	6,466,000	4,710,000
5	4,560,000	5,999,000	....
6	3,086,000	4,158,000	....

[13] See footnote 2.

[14] See footnote 6.

[15] See footnote 7.

[16] Conn, H. J. Bacteria in Frozen Soil. *Centbl. Bakt.*, Abt. II, 28:422–434, 1910. Bacteria of Frozen Soil, II. *Centbl. Bakt.*, Abt. II, 32:70–97, 1911. A Classification of the Bacteria in Two Soil Plats of Unequal Productivity. Cornell Univ. Agr. Exp. Sta., Bul. 338:65–115, 1913. Bacteria of Frozen Soil. N. Y. Agr. Exp. Sta., Tech Bul. 35:1–20, 1914.

tains agar and peptone. The term "synthetic" is justified only on the assumption that variations in these materials do not affect the growth of bacteria; but Brown states[17] that the form of nitrogen, even when used in such minute quantities, is of great importance in determining the value of the medium. The agar medium tested out in the present work, concerning which a preliminary note has already been published[18], is furnished no organic nitrogen except that contained in sodium asparaginate, and is apparently the first medium ever used for making poured plates from soil that does not contain nitrogen in the form of some indefinite chemical compound.

Table I gives the formulæ of the media preferred respectively by Fischer, by Lipman and Brown, by Temple, and by Brown in the publications already mentioned. It also gives the formulæ of the soil-extract gelatin and asparaginate agar recommended by the writer. The present work is an investigation of these six media.

Table I.— Composition of Various Culture Media for Soil Bacteriological Work

Constituents.	Fischer's soil-extract agar.	Lipman and Brown's "Synthetic" agar.	Brown's albumin agar.	Temple's peptone agar.	Soil-extract gelatin.	Asparaginate agar
Distilled water	....	1,000	1,000	....	900	1,000
Tap-water	....	....	....	1,000	....	....
Soil-extract	*1,000	....	....	....	†100	....
Agar	12	20	15	15	....	12
Gelatin	....	....	....	....	120	....
Peptone	....	0.05	....	1	....	....
Albumin	....	....	1	....	....	....
Sodium asparaginate	....	....	....	....	....	1
Dextrose	....	10	10	....	1	1
$MgSO_4$	....	0.2	0.2	....	....	0.2
K_2HPO_4	2	0.5	0.5	....	....	....
$NH_4H_2PO_4$	....	....	....	....	....	1.5
$CaCl_2$	....	....	....	....	....	0.1
KCl	....	....	....	....	....	0.1
$FeCl_3$	....	....	....	....	....	Trace
$Fe_2(SO_4)_3$	....	....	Trace	....	....	....

* Prepared by heating soil for half an hour at 15 pounds pressure with an equal weight of a 0.1 per ct. solution of Na_2CO_3.

† Prepared by boiling soil half an hour with an equal weight of distilled water (see p. 11).

[17] See footnote 11. Ia. Bul. p. 397. *Centbl.* p. 498.

[18] Conn, H. J. A New Medium for the Quantitative Determination of Bacteria in Soil. *Science*, N. S., 39:764, 1914.

GENERAL TECHNIQUE

The technique used by various soil bacteriologists has differed not only in the kinds of culture media used but also in the length of incubation and the temperature employed. The two latter factors are fully as important as the composition of the medium in determining the final count. Fischer incubated his plates at 16-20° C. and counted during the second week. Temple used a temperature of 25° C. for six days. Lipman and Brown held their plates three days at "about 25° C." This last method is open to criticism, for it has been found in the studies reported upon in this bulletin that so many new colonies continue to appear on Lipman's and Brown's media after three days that the count may be as much as three times as high on the tenth day as on the third. The counts published by Lipman and by Brown, indeed, are considerably lower than those obtained upon their media in the course of the present investigation, in which the longer incubation time has been used.

In the present work gelatin plates have been incubated for seven days, agar plates for fourteen. It would undoubtedly have been more satisfactory to hold gelatin plates a few days longer; but as liquefaction often prevents a count under these circumstances, seven days has been chosen for the routine incubation time. In the case of agar plates, on the other hand, very few new colonies develop after the tenth day, and the longer period of incubation seems to be unnecessary. The use of the fourteen-day period was begun before this fact was known, and it was continued throughout the work in order to make all the results comparable.

The temperature used for incubation has been 18° C. The incubator employed[19] is one that can be kept at a very constant temperature; and it has never reached a temperature as high as 19° except on the hottest summer days. In the case of gelatin, the use of this low temperature is very important, because it prevents rapid liquefaction.

The soils chosen for making these tests have been of as great a variety as could be obtained in this locality. They vary in texture from muck to sand. They are of the following various origins: glacial lake deposit (Dunkirk series), glacial till of the New York drumlin area (Ontario series), glacial till from Devonian shales and sandstones (Volusia silt loam), alluvial (Genesee soils) and a limestone residual soil mixed somewhat with glacial materials (Honeoye stony loam). The nomenclature used is that adopted by the Bureau of Soils of the United States Department of Agriculture.[20]

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[19] Conn, H. J., and Harding, H. A. An Efficient Electrical Incubator. N. Y. Agr. Exp. Sta., Tech. Bul. 29:1–16, 1913.

[20] U. S. Dept. Agr. Bureau of Soils, Bul. 96, pp. 1–791, 1913. See also Soil Survey of Ontario County, New York, published by this Bureau, 1912; pp. 1–55.

Each sample of soil has been plated in two different dilutions. These dilutions have varied somewhat with the different soils used; but in each test listed in this bulletin, the figures for the different media have invariably been obtained from plates of the same dilution. The dilution chosen for counting has usually permitted about one hundred colonies to develop per plate. Plates have always been made in triplicate. The counts given in the tables represent the average of the three plates, except in cases where one of the three has been lost by liquefaction or otherwise. In any case where only one of the three triplicate plates has given a reliable count, the results have been discarded or else the figures in the table have been marked doubtful.

THE SOIL-EXTRACT GELATIN.

DESCRIPTION OF THE MEDIUM.

The soil-extract gelatin has been used in routine work by the writer for five years. When first used, it was thought to be merely a makeshift that would quickly be superseded by other media upon which soil bacteria could grow more readily, but it has proved so satisfactory that it has been kept in routine use in this laboratory up to the present time, and has been included in such a large majority of the tests reported in this bulletin that it serves as a basis of comparison between the media that are not compared together directly.[21] As already mentioned it is to be recommended for qualitative work because it meets the requirement of showing distinctions in appearance between the colonies of different kinds of bacteria. The data published in this bulletin will show whether it is also adapted to the growth of as large a number of soil bacteria as are the other culture media that have been proposed for soil work.

The preparation of this gelatin is as follows: Soil, heated in an autoclave for an hour at 20 to 25 pounds pressure, is extracted by mixing with an equal weight of distilled water, allowing the mixture to stand cold for twelve hours and then boiling half an hour, restoring the water lost by evaporation, and filtering. In making up each batch of the medium, the soil-extract is diluted with distilled water to one-tenth its natural strength and used for dissolving the gelatin. (Gold Label Gelatin has always been used.) It is probably unnecessary to carry out in detail the whole of this procedure for obtaining soil-extract, but it was followed carefully throughout the present work in the hope that the composition of the soil-extract might be more nearly constant than it would be if the method of preparation were allowed to vary. After dissolving the gelatin in the diluted soil-extract, the medium is clarified by the use of the white

[21] The only caution necessary in employing this gelatin is the use of an incubation temperature as low as 18° C. See p. 28.

of egg, as generally recommended for ordinary bacteriological media. Dextrose is added just before tubing. The reaction is adjusted to 0.5 per ct. normal acid to phenolphthalein. The formula is given in the fifth column of Table I (p. 203).

VARIATIONS BETWEEN DIFFERENT BATCHES OF THE MEDIUM.

A strong objection to this gelatin is its indefinite chemical composition. Variations in the composition might easily cause irregularities in the counts. As a matter of fact, however, there has seldom been any evidence of such variation; but in Table II is given one instance where it was noticeable. This table shows the counts obtained in a series of nine platings upon three batches of soil-extract gelatin all made up from the same lot of soil-extract, although from different packages of gelatin. Batch I was two and a half months old at the time of use; batches II and III were made up fresh, but batch II had been left in a warm room over night before sterilization and a faintly noticeable decomposition had taken place. It will be seen that the counts on batch II are considerably lower than those on batch I. Batch III was used only six times. Generally it gave a count intermediate between batches I and II.

In this particular case the cause of the poor results from batch II was undoubtedly its decomposition; but the decomposition was so very slight that if it had not happened to be accompanied by gas formation, it might have been overlooked. A similar accident might easily occur in making up any batch without being noticed. There are many other opportunities for such variation in composition of the media. Agar is as liable to these variations as gelatin; again and again some batch of agar under investigation, apparently made up in exactly the same manner as the others, has proved unusually satisfactory or else unusually unsatisfactory. These irregularities, indeed, are great enough to make the result of any comparison between two media unreliable unless more than one batch of each medium has been used.

This fact does not seem to have been fully realized by some investigators. The six comparative tests given by Brown[22] were presumably made with a single batch of each medium investigated, although the author makes no statement to that effect. A glance at his figures makes it plain that the variations between the counts he obtained upon the different media are less than those shown in Table II as occurring between two different batches of gelatin, and likewise less than those known to occur between different lots of agar media.

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[22] See footnote 12.

Table II.— Tests Comparing Different Batches of Soil-Extract Gelatin.

Test No.	Date.	Soil type.	Bacteria Per Gram Dry Soil, as Determined with —		
			Batch I — $2\frac{1}{2}$ months old.	Batch II — fresh, but decomposed.	Batch III — fresh; good.
	1914.				
1	Sept. 1	Dunkirk silty clay loam. .	24,000,000	10,000,000	....
2	Sept. 2	Dunkirk silty clay loam. .	14,000,000	9,000,000	....
3	Sept. 2	Dunkirk silty clay loam. .	12,000,000	8,500,000	....
4	Sept. 5	Dunkirk silty clay loam. .	35,000,000	23,000,000	....
5	Sept. 5	Dunkirk silty clay loam. .	21,000,000	13,000,000	19,000,000
6	Sept. 10	Dunkirk silty clay loam. .	21,500,000	13,500,000	*20,000,000
7	Sept. 10	Dunkirk silty clay loam. .	39,000,000	25,000,000	32,000,000
8	Sept. 10	Dunkirk silty clay loam. .	20,000,000	14,500,000	16,500,000
9	Sept. 11	Ontario fine sandy loam. .	....	9,500,000	*9,500,000
10	Sept. 11	Ontario fine sandy loam. .	....	9,500,000	11,500,000

* These counts are inexact because of rapid liquefaction.

SIMPLIFICATION OF THE FORMULA OF THE SOIL-EXTRACT GELATIN.

The opportunity for such variations in composition seems, *a priori*, to be greater in the case of this gelatin than with any of the agar media discussed in this paper. Soil-extract is unquestionably of variable composition. Gelatin itself also may be the cause of considerable irregularity. It is more complex in chemical composition than agar and presumably more variable. It may perhaps contain fewer impurities; but it is used in ten times as large quantities as agar, which must result in the introduction of large amounts of whatever impurities it does contain. Lastly, gelatin is a food for many bacteria, and for that reason variations in its composition must have more influence upon bacterial growth than those in agar, which is not ordinarily of nutrient value for bacteria.

In the hope of eliminating some of these causes of variation, an attempt was made, toward the close of the present investigation, to simplify the formula of the gelatin. If any way of purifying the gelatin itself had been known, that would have been undertaken. In the lack of such knowledge, attention was turned to the soil-extract. Eliminating the soil-extract could not prevent the sort of variations shown in Table II, but it might prevent others equally great.

The soil-extract was first replaced by tap-water. The results were so surprisingly successful that both the tap-water and the dextrose were finally eliminated, leaving only a solution of gelatin in distilled water, clarified with white of egg. The results are given in Table III. It will be seen, first, that the tap-water gelatin with

TABLE III.— TESTS OF SIMPLIFIED GELATIN FORMULAE.

Test No.	Date.	SOIL TYPE.	BACTERIA PER GRAM DRY SOIL, AS DETERMINED WITH —					
			Gelatin, soil-extract, dextrose.	Gelatin, tap-water, dextrose.	Gelatin, tap-water.	Gelatin, distilled water, dextrose.	Gelatin, distilled water.	Gelatin, distilled water (unclarified).
	1914.							
1	Mar. 14	Dunkirk fine sand	8,000,000	*11,500,000	....	....	....	....
2	Mar. 14	Dunkirk fine sand	26,000,000	26,000,000	....	....	....	....
3	Mar. 17	Volusia silt loam	14,000,000	15,000,000	....	....	....	....
4	April 3	Dunkirk silty clay loam	31,000,000	30,000,000	....	33,000,000	30,000,000	....
5	April 3	Dunkirk silty clay loam	33,000,000	37,000,000	....	32,500,000	32,500,000	....
6	April 15	Dunkirk silty clay loam	21,500,000	....	....	....	22,000,000	....
7	April 15	Dunkirk silty clay loam	32,000,000	....	....	....	28,000,000	....
8	April 17	Volusia silt loam	10,000,000	8,000,000	....	....	9,000,000	....
9	April 17	Volusia silt loam	10,000,000	9,000,000	....	9,000,000	....	....
10	April 17	Volusia silt loam	21,000,000	....	....	14,000,000	14,000,000	....
11	April 29	Dunkirk silty clay loam	16,000,000	25,000,000	....	....	....	18,000,000
12	April 29	Dunkirk silty clay loam	15,000,000	19,000,000	16,000,000	....	....	....
13	May 2	Dunkirk silty clay loam	11,000,000	....	....	....	17,000,000	16,000,000
14	May 2	Dunkirk silty clay loam	31,000,000	....	....	....	32,000,000	19,000,000
15	May 22	Honeoye stony loam	12,000,000	....	....	....	12,500,000	10,000,000
16	May 22	Honeoye stony loam	16,000,000	....	....	12,000,000	12,000,000	....
17	May 29	Dunkirk silty clay loam	20,000,000	18,000,000	16,000,000	....	....	....
18	June 4	(A soil from Colorado)	35,000,000	36,000,000	33,000,000	....	....	....
19	June 4	(A soil from Colorado)	9,000,000	10,000,000	10,000,000	....	....	....
20	June 5	Norfolk sand	2,000,000	....	1,200,000	....	1,000,000	....
21	June 5	(A soil from No. Dakota)	6,500,000	6,000,000	....	5,800,000	....	....
22	Aug. 5	Volusia silt loam	9,500,000	....	10,600,000	....	10,300,000	....
23	Aug. 5	Volusia silt loam	12,500,000	....	12,000,000	....	10,000,000	....
24	Aug. 6	Volusia silt loam	8,300,000	....	8,000,000	....	6,700,000	....
25	Aug. 6	Volusia silt loam	†13,000,000	....	8,800,000	....	7,200,000	....

26	Aug. 6	Volusia silt loam...........	9,500,000	....	6,000,000	....	6,300,000	....
27	Aug. 8	Ontario loam..............	†22,000,000	....	†19,000,000	....	21,000,000	....
28	Aug. 8	Ontario loam..............	25,000,000	....	**27,500,000**	....	22,800,000	....
29	Aug. 10	Volusia silt loam...........	†5,500,000	....	4,500,000	....	3,600,000	....
30	Aug. 10	Volusia silt loam...........	8,500,000	....	5,800,000	....	7,000,000	....
31	Aug. 11	Volusia silt loam...........	10,500,000	....	7,700,000	....	8,000,000	....
32	Aug. 11	Volusia silt loam...........	13,500,000	....	9,600,000	....	7,200,000	....
33	Aug. 19	Dunkirk silty clay loam......	23,500,000	....	†22,000,000	....	23,000,000	....
34	Aug. 19	Dunkirk silty clay loam......	29,000,000	....	22,000,000	....	‡28,000,000	....
35	Sept. 1	Dunkirk silty clay loam......	24,000,000	16,000,000	....	18,000,000	....	....
36	Sept. 2	Dunkirk silty clay loam......	14,000,000	11,000,000	....	10,500,000	....	....
37	Sept. 2	Dunkirk silty clay loam......	12,000,000	**13,000,000**	....	8,800,000	....	....
38	Sept. 5	Dunkirk silty clay loam......	35,000,000	25,000,000	....	25,000,000	....	....
39	Sept. 5	Dunkirk silty clay loam......	24,000,000	17,500,000	....	16,000,000	....	....
40	Sept. 10	Dunkirk silty clay loam......	20,000,000	16,500,000	....	16,500,000	....	....
41	Sept. 10	Dunkirk silty clay loam......	32,000,000	28,500,000	....	28,000,000	....	....
42	Sept. 10	Dunkirk silty clay loam......	16,500,000	14,500,000	....	17,000,000	....	....
43	Oct. 23	Dunkirk silty clay loam......	†22,000,000	21,000,000	....	....	....	....
44	Oct. 23	Dunkirk silty clay loam......	30,000,000	†30,000,000	....	....	....	....
45	Oct. 23	Dunkirk silty clay loam......	29,000,000	**32,000,000**	....	....	....	....
46	Oct. 28	Dunkirk silty clay loam......	6,200,000	**6,800,000**	....	....	....	....
47	Nov. 5	Dunkirk silty clay loam......	18,000,000	17,300,000	....	....	....	....
48	Nov. 5	Dunkirk silty clay loam......	22,000,000	20,000,000	....	....	....	....
49	Nov. 6	Dunkirk silty clay loam......	22,000,000	‡20,000,000	....	....	....	....
50	Nov. 6	Dunkirk silty clay loam......	16,000,000	**19,000,000**	....	....	....	....

* Those counts on the simplified formulae that are higher than the corresponding counts on soil-extract gelatin are printed in bold-faced type.

† These counts are inexact because of rapid liquefaction.

‡ In these cases there was such irregularity between the number of colonies upon the parallel plates that satisfactory averages could not be made.

dextrose has given a higher count than the soil-extract gelatin quite often in the earlier tests but only four times in the last sixteen. As different batches of the media were used in the earlier and later tests, it is quite possible that the variation in the counts may have arisen from this cause alone. Secondly it will be seen that the tap-water gelatin without dextrose has rarely given a count as high as that on soil-extract gelatin; but that all the differences are too slight to show an actual advantage for either formula. Thirdly, it will be noticed that the counts on distilled water gelatin with or without dextrose are still more rarely equal to those on the soil-extract gelatin. In this case also the differences are so slight that their significance is doubtful. These tests cannot be construed as showing any reason for using soil-extract rather than tap-water or even distilled water. If further tests show similar results one of the simpler formulæ will unquestionably be considered superior for routine work.

These tests show that either the gelatin, itself, or the white of egg used in clarification has furnished the bacteria with sufficient nutrient matter to cause large numbers of them to develop into colonies. To determine which of these sources was the more important a solution of gelatin was made in distilled water and then used without clarification. The counts obtained on it are given in the last column of Table III. Only four tests of this medium were made; but in two of them the count was higher and in one other almost as high as on the clarified soil-extract gelatin. In spite of the small number of tests made, it seems safe to conclude that gelatin is in itself a very satisfactory culture medium for soil-bacteria.

The use of the soil-extract gelatin was continued, however, throughout the present investigation even though one of the simpler formulæ might have given as good results. Its employment in the earlier work made its continued use valuable as a basis of comparison, and it is plain that the simpler formulæ do not give any better results. A further discussion of the merits of this gelatin follows (pp. 219 to 226) in connection with the discussion of the tables in which it is compared with various agar media.

THE ASPARAGINATE AGAR.

DESCRIPTION OF THE MEDIUM.

The asparaginate agar is intended primarily for quantitative work, as it contains no substance of indefinite chemical composition except the agar itself; but it does not allow such great differences in the appearance of the different colonies as does gelatin. The comparative tests which follow (pp. 219 to 226) will show whether it meets the other important requirement of a medium for quantitative work, that of allowing the growth of the greatest possible number of soil bacteria.

The sole form of organic nitrogen in this agar medium is sodium asparaginate. The formula is given in Table I (p. 203). It is much like the formulæ recommended by Lipman and by Brown, its principal differences being that nitrogen is furnished in the form of definite chemical compounds only (sodium asparaginate and ammonia phosphate), that it contains only 0.1 per ct. instead of 1 per ct. dextrose, and that it contains the ions Ca and Cl which Lipman and Brown do not use.

In the preparation of the asparaginate agar, the dextrose and sodium asparaginate have been added just before sterilization, so as to avoid any possible effects of the preliminary heating on these substances. The reaction has always been carefully adjusted; because if the acidity is as high as 1.5 per ct. normal (using phenolphthalein as an indicator) the count is appreciably lowered (see Table VIII, p. 219). If it is as low as 0.5 per ct. normal, there is danger of decomposing the ammoniun phosphate and losing the ammonia. The reaction should be between 0.8 per ct. and 1.0 per ct. normal acid to phenolphthalein.[23]

Considerable difficulty has been experienced in clarifying this medium by the ordinary procedure, using the white of egg. Sufficient clarification can be accomplished, however, by heating the medium half an hour at 15 pounds steam pressure in such a way as not to disturb the sediment, and then decanting through a cotton filter. This method of clarification is simpler and is really preferable to the use of white of egg, as it does not introduce into the medium any material of indefinite composition.

TESTS TO DETERMINE THE MOST SATISFACTORY FORMULA.

The exact formula given for this agar in Table I is not to be considered as the only satisfactory combination possible. Tables IV to VIII show the results of a few tests bearing on this point. The conclusions that may be drawn from these tables are somewhat limited by the small number of tests made. The same irregularity between different batches of the medium already mentioned for gelatin probably also occurs with the agar. The differences shown in these tables between the counts obtained upon the different media are undoubtedly less than those that might be obtained with different batches of the same medium. The small number of tests made, therefore, can furnish only indications. To establish any actual difference between the various media would require a long series of tests, for which time was lacking in the present investigation. Lack of time has also made it impossible to test out any but the most significant points.

The first point tested was to determine the most satisfactory amount of asparaginate to use. It was found possible to vary this considerably without affecting the results. This is shown by the first four columns of Table IV. The usual formula containing 0.1

[23] This ordinarily requires just 10 c.c. of normal sodium hydroxide per litre.

TABLE IV.— TESTS TO DETERMINE THE EFFECT OF VARYING THE AMOUNT OF SODIUM ASPARAGINATE IN ASPARAGINATE AGAR.

Test No.	Date.	Soil Type.	Bacteria Per Gram Dry Soil, as Determined with —						
			Agar media as in Table I, column VI, containing —						Soil-extract gelatin.
			0.5 per ct. asparaginate.	0.2 per ct. asparaginate.	0.1 per ct. asparaginate.	0.05 per ct. asparaginate.	0.02 per ct. asparaginate.	No asparaginate.	
	1913.								
1	May 26	Dunkirk fine sandy loam	....	*15,000,000	13,500,000	....	....	....	12,000,000
2	June 2	Volusia silt loam.......	....	13,500,000	17,000,000	....	....	....	16,000,000
3	Sept. 6	Dunkirk gravelly loam..	11,000,000	....	13,000,000	....	....	....	12,000,000
4	Sept. 15	Dunkirk loam..........	6,000,000	....	7,000,000	....	....	....	8,000,000
	1914.								
5	Jan. 16	Dunkirk silty clay loam..	....	....	5,000,000	**16,500,000**	....	....	19,000,000
6	Jan. 16	Dunkirk silty clay loam..	....	....	5,500,000	**12,000,000**	....	....	18,000,000
7	Jan. 16	Dunkirk silty clay loam..	....	....	12,000,000	**17,500,000**	....	....	35,000,000
8	Jan. 19	Ontario fine sandy loam..	....	....	15,000,000	**20,000,000**	....	....	27,000,000
9	Jan. 19	Ontario fine sandy loam..	....	....	14,500,000	**22,000,000**	....	....	22,000,000
10	Jan. 24	Dunkirk silty clay loam.	....	....	22,000,000	10,000,000	....	....	25,000,000
11	Jan. 24	Dunkirk silty clay loam.	....	....	39,000,000	20,000,000	....	....	48,000,000
12	April 7	Dunkirk silty clay loam.	....	....	24,000,000	23,000,000	....	....	30,000,000
13	April 7	Dunkirk silty clay loam.	....	....	27,000,000	24,000,000	....	....	31,000,000
14	April 15	Dunkirk silty clay loam.	....	....	13,000,000	**16,000,000**	....	....	23,000,000
15	April 24	Volusia silt loam.......	....	....	11,000,000	**12,000,000**	....	....	10,000,000
16	April 24	Volusia silt loam.......	....	....	15,000,000	**18,000,000**	....	....	12,000,000
17	April 24	Volusia silt loam.......	....	....	16,000,000	15,000,000	....	....	14,500,000
18	May 9	Dunkirk fine sand......	....	....	10,500,000	....	....	9,500,000	10,000,000
19	May 14	Dunkirk silty clay loam.	....	....	27,000,000	....	....	21,000,000	†20,000,000
20	May 14	Dunkirk silty clay loam.	....	....	28,000,000	....	....	23,000,000	26,000,000
21	May 18	Ontario fine sandy loam.	....	....	27,000,000	....	....	18,000,000	20,000,000
22	May 18	Ontario fine sandy loam.	....	....	29,000,000	**36,000,000**	....	....	†25,000,000
23	May 26	Volusia silt loam.......	....	....	9,000,000	9,000,000	6,000,000	....	....

24	May 26	Volusia silt loam......	....	....	11,000,000	**13,000,000**	**11,500,000**	....	....
25	May 28	Ontario fine sandy loam.	....	....	20,000,000	....	19,000,000	....	23,000,000
26	May 28	Ontario fine sandy loam.	....	....	18,000,000	....	17,000,000	....	21,000,000
27	May 29	Dunkirk silty clay loam.	....	....	19,500,000	....	16,000,000	....	†20,000,000

* Counts upon the modified formulae that are higher than the corresponding counts upon the medium with 0.1 per ct. asparaginate are printed in bold-faced type.

† These counts are inexact because of rapid liquefaction.

per ct. asparaginate (see column three) was first compared with two modified formulæ containing 0.2 per ct. and 0.5 per ct. of asparaginate respectively (see columns one and two). As each of these formulæ was used in only two tests no definite conclusions can be drawn, but it is evident that there is no distinct advantage to be gained by using these larger quantities of asparaginate. A much longer series of tests was made of a medium containing only 0.05 per ct. asparaginate (see the fourth column). In ten of the sixteen cases the counts obtained with 0.05 per ct. asparaginate are higher than those obtained with 0.1 per ct.; while 0.1 per ct. of asparaginate has allowed better counts only in five cases. The slight superiority of the medium with the smaller amount of asparaginate may have been merely accidental; but it is quite plain that as good results can be obtained with 0.05 per ct. as with larger amounts. As the asparaginate is the most expensive constituent of the medium, perhaps it would be well in routine work to use 0.05 per ct. instead of 0.01 per ct. (as given in Table I). The results are less satisfactory, however, when the asparaginate has been lowered beneath this point. In the fifth column five counts on a medium containing only 0.02 per ct. sodium asparaginate are given, and in the sixth column four counts on a medium with the asparaginate omitted entirely. All these counts except one (test No. 21 with 0.02 per ct. asparaginate) were lower than the corresponding counts when 0.1 per ct. of asparaginate was used, but the differences were never very great. The greatest disadvantage of these two media cannot be shown by figures. Colonies developed very slowly upon them and remained small and undifferentiated in appearance. Although it is not absolutely necessary for a medium intended for quantitative work to show differences in appearance between the colonies of different kinds of bacteria, it is, nevertheless, a desirable feature if it can be obtained without sacrificing either of the other two more necessary qualifications. For this reason it is not advisable to use less than 0.05 per ct. of sodium asparaginate, even though it may be entirely omitted without greatly affecting the count.

A second series of tests, showing the effect of varying the dextrose content, is given in Table V. The six counts given in the first two columns indicate an inferiority when as much as 0.5 per ct. of dextrose is used, but the tests are too few in number to establish the fact. More work on this point is to be desired. It would be advantageous to use larger amounts of dextrose if it could be done without lowering the count, because this sugar is of considerable value in bringing out distinctions between the colonies of different kinds of bacteria. The counts given in the fourth column of this table would seem to show that reducing the dextrose content to 0.05 per ct. has lessened the number of colonies which develop; but

Table V.— Tests to Determine the Effect of Varying the Amount of Dextrose in Asparaginate Agar.

Test No.	Date.	Soil Type.	Bacteria per Gram Dry Soil, as Determined with— Asparaginate agar containing— 1 per ct. dextrose	0.5 per ct. dextrose	0.1 per ct. dextrose	0.05 per ct. dextrose	Soil-extract gelatin
	1913						
1	May 26	Dunkirk fine sandy loam	....	*10,000,000	13,500,000	....	12,000,000
2	June 2	Volusia silt loam	....	7,000,000	17,000,000	....	16,000,000
3	June 4	Dunkirk sandy loam	....	†3,000,000	7,000,000	....	7,500,000
4	June 24	Ontario loam	....	....	21,000,000	16,000,000	22,000,000
5	July 10	Dunkirk silty clay loam	....	....	17,500,000	12,500,000	22,000,000
6	Sept. 6	Dunkirk gravelly loam	....	....	13,000,000	11,000,000	12,000,000
	1914						
7	Oct. 27	Dunkirk silty clay loam	5,000,000	....	11,000,000	....	16,000,000
8	Oct. 30	Dunkirk silty clay loam	7,500,000	....	16,000,000	....	11,000,000
9	Oct. 30	Dunkirk silty clay loam	9,500,000	....	17,000,000	....	17,000,000

* The counts with these modified agar formulæ were always lower than the corresponding counts when 0.1 per ct. dextrose was employed; hence no bold-faced type is used in this table.

† The medium used in making this count contained 0.2 per ct. asparaginate.

some further tests are given in Table VI in which the use of 0.05 per ct. of dextrose has had no appreciable influence. This latter table contains thirteen comparative counts between the formula given in Table I (with 0.1 per ct. dextrose and 0.1 per ct. asparaginate) and a modified formula in which the asparaginate content is

TABLE VI.— TESTS TO DETERMINE THE EFFECT OF USING ONLY .05 PER CT. DEXTROSE IN ASPARAGINATE AGAR.

Test No.	Date.	SOIL TYPE.	BACTERIA PER GRAM DRY SOIL, AS DETERMINED WITH —		
			ASPARAGINATE AGAR CONTAINING —		Soil-extract gelatin
			0.1 per ct. dextrose	0.05 per ct. dextrose*	
	1913.				
1	Sept. 15	Dunkirk loam..............	7,000,000	†**9,500,000**	8,000,000
2	Sept. 24	Muck.....................	23,000,000	**24,000,000**	29,000,000
3	Oct. 4	Ontario fine sandy loam......	4,500,000	**7,000,000**	7,000,000
4	Oct. 8	Volusia silt loam...........	4,500,000	**9,500,000**	9,300,000
5	Oct. 8	Volusia silt loam...........	4,000,000	**7,500,000**	9,800,000
6	Oct. 22	Genesee loam..............	19,000,000	**22,500,000**	27,000,000
7	Oct. 27	Muck.....................	74,000,000	70,000,000	118,000,000
8	Nov. 18	Dunkirk fine sand..........	6,500,000	**7,800,000**	8,000,000
9	Nov. 18	Dunkirk fine sand..........	6,000,000	**7,500,000**	9,000,000
10	Nov. 25	Dunkirk silty clay loam.....	9,500,000	**10,500,000**	16,000,000
11	Dec. 5	Ontario fine sandy loam.....	18,000,000	‡17,000,000	19,000,000
12	Dec. 5	Ontario fine sandy loam.....	18,000,000	17,000,000	24,000,000
13	Dec. 15	Dunkirk silty clay loam.....	12,500,000	10,500,000	12,000,000

* This medium contained 0.2 per ct. asparaginate.

† Counts on the asparaginate agar with 0.05 per ct. dextrose that are higher than the corresponding counts upon the medium with 0.1 per ct. dextrose are printed in bold-faced type.

‡In this case there was such irregularity between the number of colonies upon the parallel plates that a satisfactory average could not be taken.

doubled but only half the usual amount of dextrose is used. The count has proved higher on the modified formula than on the ordinary asparaginate agar in all but four cases, and equal to it in one of those four; but the counts on the two media are always so nearly the same that no weight can be attached to the differences between them. It is plain that, if reducing the amount of dextrose has had any influence upon the count, that influence has been neutralized by increasing the amount of asparaginate, a result which is not to be expected in view of the data given in Table IV,

showing that variations in the amount of asparaginate have no appreciable effect upon the number of colonies that develop. For quantitative purposes, 0.05 per ct. dextrose seems to be as good as 0.1 per ct. Possibly the dextrose could be entirely omitted without causing a lower count. In fact a single test in which a formula was used differing from that of Table I only in the absence of dextrose, resulted in exactly the same count as obtained with the use of 0.1 per ct. dextrose.[24] No further tests were made with this formula as the colonies developing on it were all very small and alike in appearance.

A further series of tests was made to see if the formula of this medium could be simplified. In Table VII the counts obtained by the use of three agar media of more simple composition are compared with those made on the ordinary formula. One of the simpler media is a mixture of agar, tap-water, 0.1 per ct. of sodium asparaginate and 0.1 per ct. of dextrose; the second the same with the dextrose omitted; and the third a mixture of agar and tap-water alone. This comparison was made in the hope that tap-water might supply all the necessary mineral salts. Only two tests were made of tap-water and agar alone, because, although this medium allowed a fairly high count, the colonies were all small and of the same appearance. When sodium asparaginate was added to this tap-water agar, however, the results were fairly satisfactory, and with the further addition of dextrose more satisfactory still, but the colonies were not even then as large as when the formula given in Table I was used, and the count was usually lower. This attempt at simplification cannot be considered a success.

It has already been mentioned that a most important point in the composition of the asparaginate agar is its reaction. There is very little data available to prove this point by direct comparison, although it has been well established in the course of the present work. The fact was learned largely by noticing that whenever the medium was made up by accident with a reaction as high as 1.5 per ct. normal acid, the counts obtained were always much lower than expected. This was so very evident that a few additional direct tests were considered enough to settle the matter. They are given in Table VIII. The four tests all agree in showing that the count is about twice as high when the reaction is 0.8 per ct. as when it is 1.5 per ct. Additional weight is given to these figures by the fact that tests Nos. 1 and 2 were made with different batches of media from those used in Nos. 3 and 4, the media used in the last two tests having a slightly different formula from usual (0.05 per ct. dextrose and 0.2 per ct. asparaginate). No media were tested out with a reaction more alkaline than 0.8 per ct. acid, because of the danger of losing the ammonia of ammonium phosphate unless the medium was

[24] This test is not included in any of the tables.

TABLE VII.— TESTS OF SIMPLIFIED FORMULAE FOR ASPARAGINATE AGAR.

Test No.	Date.	SOIL TYPE.	BACTERIA PER GRAM DRY SOIL, AS DETERMINED WITH —				
				SIMPLIFIED FORMULAE, CONTAINING —			
			Asparaginate agar, as given in Table I.	Agar, tap-water, sodium asparaginate and dextrose.	Agar, tap-water, and sodium asparaginate.	Agar and tap-water.	Soil-extract gelatin.
	1914.						
1	May 9	Dunkirk fine sand	10,500,000	....	....	***11,000,000**	10,000,000
2	May 9	Dunkirk fine sand	....	....	....	10,000,000	11,000,000
3	May 19	Dunkirk sandy loam	6,000,000	....	5,000,000	....	4,000,000
4	May 19	Dunkirk sandy loam	7,500,000	....	7,000,000	....	‡9,000,000
5	May 21	Muck	160,000,000	....	**210,000,000**	....	180,000,000
6	May 21	Muck	92,000,000	....	**100,000,000**	....	‡100,000,000
7	Aug. 27	Dunkirk silty clay loam	20,000,000	16,000,000	16,000,000	....	†17,000,000
8	Aug. 27	Dunkirk silty clay loam	16,000,000	9,700,000	9,200,000	....	†10,000,000
9	Aug. 28	Ontario loam	33,000,000	23,000,000	22,000,000	....	†23,000,000
10	Aug. 28	Ontario loam	42,000,000	22,000,000	18,500,000	....	†32,000,000
11	Aug. 31	Dunkirk silty clay loam	25,000,000	21,000,000	19,000,000	....	†20,000,000
12	Aug. 31	Dunkirk silty clay loam	20,000,000	16,000,000	15,000,000	....	†19,000,000
13	Sept. 1	Dunkirk silty clay loam	36,000,000	28,000,000	33,000,000	....	†35,000,000
14	Sept. 1	Dunkirk silty clay loam	22,000,000	16,000,000	15,000,000	....	24,000,000
15	Sept. 2	Dunkirk silty clay loam	15,000,000	12,000,000	11,500,000	....	14,000,000
16	Sept. 2	Dunkirk silty clay loam	13,000,000	9,200,000	9,000,000	....	12,000,000
17	Sept. 5	Dunkirk silty clay loam	30,000,000	24,000,000	24,000,000	....	35,000,000
18	Sept. 5	Dunkirk silty clay loam	21,000,000	17,000,000	17,000,000	....	24,000,000

* Counts on the simplified formulæ that are higher than the corresponding counts upon the full formula for asparaginate agar are printed in bold-faced type.

† Counts made with tap-water gelatin, instead of soil-extract gelatin.

‡ These counts are inexact because of rapid liquefaction.

distinctly acid in reaction. These tests bear out the generally admitted fact that media for soil work should have a reaction between 0.5 per ct. and 1.0 per ct. normal acid to phenolphthalein.

TABLE VIII.— TESTS TO DETERMINE THE EFFECT OF VARYING THE REACTION OF ASPARAGINATE AGAR.

Test No.	Date.	Soil Type.	Bacteria per Gram Dry Soil, as Determined on Asparaginate Agar with a Reaction of	
			0.8 per ct. acid.	1.5 per ct. acid.
	1913.			
1	Dec. 5	Ontario fine sandy loam........	18,000,000	8,500,000
2	Dec. 5	Ontario fine sandy loam........	18,000,000	7,500,000
3*	Dec. 5	Ontario fine sandy loam........	17,000,000	7,000,000
4*	Dec. 5	Ontario fine sandy loam........	17,000,000	9,000,000

* Tests Nos. 3 and 4 were made with different batches of media from the first two tests. The media used in Nos. 3 and 4 contained 0.05 per ct. dextrose and 0.2 per ct. asparaginate, instead of the usual amounts.

TESTS COMPARING THE VARIOUS MEDIA.

A series of tests was made comparing the soil extract gelatin and the asparaginate agar with the other solid media that have been recommended for soil bacteria. Table IX is a comparison between the counts obtained upon the asparaginate agar and parallel counts upon the soil-extract gelatin. In Tables X to XIII the counts upon these two media are compared with those upon the media recommended by Fischer, by Lipman and Brown, by Temple and by Brown.

In fifty-nine of the ninety-six comparative tests given in Table IX, the soil-extract gelatin gave higher counts than the asparaginate agar. In thirty-four cases the counts upon the agar were higher, and in three cases both media gave the same count. These tests show that the gelatin medium is rather better than the agar medium if we judge by the number of soil bacteria that grow upon it. In the matter of distinctions in appearance between colonies of different bacteria, it has already been stated that the gelatin is the more satisfactory; but the requirement of definite chemical composition is more nearly met by the agar. From these facts it may be concluded that the gelatin is best for qualitative work, the agar best for quantitative work. One other disadvantage of the gelatin, its rapid liquefaction by certain organisms, constitutes a further

TABLE IX.— TESTS COMPARING THE SOIL-EXTRACT GELATIN WITH THE ASPARAGINATE AGAR.

Test No.	Date.	Soil Type.	Bacteria per Gram Dry Soil, as Determined with —		Test No.	Date.	Soil Type.	Bacteria per Gram Dry Soil, as Determined with —	
			Soil-extract gelatin.	Asparaginate agar.				Soil-extract gelatin.	Asparaginate agar.
	1913.								
1	April 4	Dunkirk silty clay loam....	***27,000,000**	**27,000,000**	49	Feb. 20	Dunkirk silty clay loam..	58,000,000	**65,500,000**
2	April 5	Volusia silt loam..........	19,000,000	**26,000,000**	50	Feb. 20	Dunkirk silty clay loam..	48,000,000	**75,000,000**
3	April 14	Dunkirk silty clay loam....	**28,000,000**	25,000,000	51	Feb. 26	Dunkirk silty clay loam..	38,000,000	**44,000,000**
4	April 14	Dunkirk silty clay loam....	**48,000,000**	47,000,000	52	Feb. 26	Dunkirk silty clay loam..	**59,000,000**	52,000,000
5	April 21	Dunkirk silty clay loam....	**33,000,000**	29,000,000	53	Feb. 27	Dunkirk fine sand.......	57,000,000	**90,000,000**
6	April 24	Ontario fine sandy loam....	23,000,000	**24,500,000**	54	Feb. 27	Dunkirk fine sand.......	95,000,000	**97,000,000**
7	May 13	Honeoye stony loam.......	28,000,000	**29,000,000**	55	Feb. 28	Dunkirk silty clay loam..	42,000,000	**54,000,000**
8	May 26	Dunkirk fine sandy loam...	12,000,000	**13,500,000**	56	Feb. 28	Dunkirk silty clay loam..	**71,000,000**	65,000,000
9	June 2	Volusia silt loam..........	16,000,000	**17,000,000**	57	Mar. 14	Dunkirk fine sand.......	8,000,000	**12,500,000**
10	June 4	Dunkirk sandy loam.......	**7,500,000**	7,000,000	58	Mar. 14	Dunkirk fine sand.......	**26,000,000**	25,500,000
11	June 26	Volusia silt loam..........	15,000,000	**16,000,000**	59	Mar. 17	Volusia silt loam........	14,000,000	**15,500,000**
12	July 10	Dunkirk silty clay loam....	**22,000,000**	17,500,000	60	April 7	Dunkirk silty clay loam..	**30,000,000**	24,000,000
13	July 14	Muck....................	**35,000,000**	26,500,000	61	April 7	Dunkirk silty clay loam..	**31,000,000**	27,000,000
14	Sept. 6	Dunkirk gravelly loam.....	12,000,000	**13,000,000**	62	April 15	Dunkirk silty clay loam..	**21,500,000**	13,000,000
15	Sept. 15	Dunkirk loam.............	**8,000,000**	7,000,000	63	April 15	Dunkirk silty clay loam..	**23,000,000**	13,000,000
16	Sept. 24	Muck....................	**29,000,000**	23,000,000	64	April 15	Dunkirk silty clay loam..	**32,000,000**	19,000,000
17	Oct. 4	Ontario loam.............	**7,000,000**	4,500,000	65	April 24	Volusia silt loam........	10,000,000	**11,000,000**
18	Oct. 8	Volusia silt loam..........	**8,700,000**	5,000,000	66	April 24	Volusia silt loam........	12,000,000	**15,000,000**
19	Oct. 8	Volusia silt loam..........	**9,300,000**	4,500,000	67	April 24	Volusia silt loam........	14,500,000	**16,000,000**
20	Oct. 8	Volusia silt loam..........	**9,000,000**	5,000,000	68	May 9	Dunkirk fine sand.......	10,000,000	**10,500,000**
21	Oct. 8	Volusia silt loam..........	**9,800,000**	4,000,000	69	May 14	Dunkirk silty clay loam..	†20,000,000	**27,000,000**
22	Oct. 22	Genesee loam.............	**30,000,000**	18,500,000	70	May 14	Dunkirk silty clay loam..	26,000,000	**28,000,000**
23	Oct. 22	Genesee loam.............	**23,500,000**	19,000,000	71	May 18	Ontario fine sandy loam..	20,000,000	**27,000,000**
24	Oct. 27	Muck....................	**118,000,000**	74,000,000	72	May 18	Ontario fine sandy loam..	†25,000,000	**29,000,000**
25	Nov. 18	Dunkirk fine sand.........	**8,000,000**	6,500,000	73	May 19	Dunkirk sandy loam.....	4,000,000	**6,000,000**
26	Nov. 18	Dunkirk fine sand.........	**9,000,000**	6,000,000	74	May 19	Dunkirk sandy loam.....	**†9,000,000**	7,500,000
27	Nov. 20	Ontario fine sandy loam....	**27,500,000**	‡20,000,000	75	May 21	Muck.................	**180,000,000**	160,000,000
28	Nov. 20	Ontario fine sandy loam....	**21,000,000**	‡18,000,000	76	May 21	Muck.................	**†100,000,000**	92,000,000
29	Nov. 25	Dunkirk silty clay loam....	**16,000,000**	10,000,000	77	May 28	Ontario fine sandy loam..	**23,000,000**	20,000,000
30	Dec. 1	Dunkirk fine sand.........	**8,800,000**	8,300,000	78	May 28	Ontario fine sandy loam..	**21,000,000**	18,000,000
31	Dec. 1	Dunkirk fine sand.........	**7,500,000**	**7,500,000**	79	May 29	Dunkirk silty clay loam..	**†20,000,000**	19,500,000
32	Dec. 5	Ontario fine sandy loam....	**19,000,000**	18,000,000	80	Aug. 5	Volusia silt loam........	**9,500,000**	8,000,000
33	Dec. 5	Ontario fine sandy loam....	**24,000,000**	18,000,000	81	Aug. 5	Volusia silt loam........	**12,500,000**	7,500,000
34	Dec. 11	Dunkirk silty clay loam....	**16,000,000**	**16,000,000**	82	Aug. 6	Volusia silt loam........	8,300,000	**11,500,000**
35	Dec. 11	Dunkirk silty clay loam....	**22,000,000**	‡18,000,000	83	Aug. 6	Volusia silt loam........	10,000,000	**12,000,000**

36	Dec. 15	Dunkirk silty clay loam....	12,000,000	**12,500,000**	84	Aug. 6	Volusia silt loam........	**9,500,000**	6,700,000
37	Dec. 15	Dunkirk silty clay loam....	**14,000,000**	10,500,000	85	Aug. 7	Dunkirk silty clay loam..	§9,000,000	**14,500,000**
	1914.								
38	Jan. 16	Dunkirk silty clay loam....	**19,000,000**	5,000,000	86	Aug. 7	Dunkirk silty clay loam..	10,000,000	**11,000,000**
39	Jan. 16	Dunkirk silty clay loam....	**18,000,000**	5,500,000	87	Aug. 8	Ontario loam...........	**21,000,000**	9,000,000
40	Jan. 16	Dunkirk silty clay loam....	**35,000,000**	12,000,000	88	Aug. 8	Ontario loam...........	**25,000,000**	16,000,000
41	Jan. 19	Ontario fine sandy loam....	**27,000,000**	15,000,000	89	Aug. 10	Volusia silt loam........	5,000,000	**5,500,000**
42	Jan. 19	Ontario fine sandy loam....	**22,000,000**	14,500,000	90	Aug. 10	Volusia silt loam........	**8,500,000**	7,000,000
43	Jan. 24	Dunkirk silty clay loam....	**25,000,000**	22,000,000	91	Aug. 11	Volusia silt loam........	**10,500,000**	6,000,000
44	Jan. 24	Dunkirk silty clay loam....	**48,000,000**	39,000,000	92	Sept. 1	Dunkirk silty clay loam..	**24,000,000**	22,000,000
45	Jan. 28	Dunkirk silty clay loam....	†60,000,000	**70,000,000**	93	Sept. 2	Dunkirk silty clay loam..	14,000,000	**15,000,000**
46	Jan. 28	Dunkirk silty clay loam....	**56,000,000**	36,000,000	94	Sept. 2	Dunkirk silty clay loam..	12,000,000	**13,000,000**
47	Jan. 30	Dunkirk silty clay loam....	**33,000,000**	22,500,000	95	Sept. 5	Dunkirk silty clay loam..	**35,000,000**	30,000,000
48	Jan. 30	Dunkirk silty clay loam....	**34,000,000**	15,000,000	96	Sept. 5	Dunkirk silty clay loam..	**24,000,000**	21,000,000

* The higher count in each test is printed in bold-faced type.
† These counts are inexact because of rapid liquefaction.
‡ The medium used in making these counts contained 0.05 per ct. dextrose and 0.2 per ct. sodium asparaginate.
§ The medium used in making this count was tap-water gelatin without dextrose.

objection to its use in quantitative work. Although the liquefaction is slower than on beef-extract-peptone gelatin, still at times it proceeds so rapidly as to prevent any count. The most efficient method found to inhibit the growth of the liquefiers without stopping the growth of other bacteria is to use an incubation temperature that does not exceed 18° C. It seems possible, indeed, that the rapid liquefaction which has so often led soil bacteriologists to regard gelatin with disfavor may have resulted from their use of a temperature of 20–21° C. for incubation. With the use of a sufficiently low temperature there has seldom been any great trouble in keeping the gelatin plates seven days before counting. Low temperatures are advisable whether the medium is to be used for qualitative or quantitative purposes, although more necessary in the latter case than in the former.[25] The asparaginate agar, on the other hand, can be used even when low temperatures are unavailable.

Table X.— Tests of Fischer's Culture Medium.

Test No.	Date.	Soil Type.	Bacteria per Gram Dry Soil, as Determined with —		
			Asparaginate agar.	Fischer's agar.	Soil-extract gelatin.
	1913.				
1	Apr. 21	Dunkirk silty clay loam. .	29,000,000	42,000,000	33,000,000
2	Oct. 4	Ontario fine sandy loam. .	4,500,000	11,500,000	7,000,000
3	Oct. 8	Volusia silt loam.	5,000,000	16,000,000	8,700,000
4	Nov. 24	Dunkirk silty clay loam. .	†14,000,000	17,000,000	**21,000,000**
5	Nov. 25	Dunkirk silty clay loam. .	9,500,000	13,000,000	**16,000,000**
6	Dec. 26	Dunkirk silty clay loam. .	***26,000,000**	25,000,000	Liquefied
7	Dec. 26	Dunkirk silty clay loam. .	**37,000,000**	32,000,000	Liquefied

* Counts upon the asparaginate agar and upon soil-extract gelatin that are higher than the corresponding counts upon Fischer's agar are printed in bold-faced type.

† The medium used in making this count contained 0.2 per ct. asparaginate and only 0.05 per ct. dextrose.

A comparison between the counts obtained on the gelatin and on the other soil media may be obtained from the figures given in Tables X to XIII. Fischer's agar, in the series of tests listed in Table X, gave a higher count than the gelatin three times out of five, in those listed in Table XIII only four times out of twelve. Lipman and Brown's agar gave a higher count than the gelatin in

[25] Liquefaction may also be checked by using 20 per ct. instead of 12 per ct. gelatin. This does not seem to lower the number of colonies.

only two of the twenty-two tests listed in Tables XI and XIII. Brown's agar gave as high a count as the gelatin only once in the nine tests given in Table XII, and four times in the twelve tests of Table XIII. Temple's agar gave a higher count than the gelatin in just three of the twelve tests listed in Table XIII. These counts show that these four agar media, like the asparaginate agar, permit the growth of fewer soil bacteria than does the gelatin. None of them allow as good distinction in appearance between the different

Table XI.— Tests of Lipman and Brown's Culture Medium.

Test No.	Date.	Soil Type.	Bacteria Per Gram Dry Soil, as Determined with —		
			Asparaginate agar.	Lipman and Brown's agar.	Soil-extract gelatin.
	1913.				
1	Apr. 21	Dunkirk silty clay loam. .	*29,000,000	20,000,000	33,000,000
2	Jan. 16	Dunkirk silty clay loam. .	†16,500,000	7,500,000	19,000,000
3	Jan. 16	Dunkirk silty clay loam. .	†12,000,000	6,500,000	18,000,000
4	Jan. 16	Dunkirk silty clay loam. .	†17,00,000	8,800,000	35,000,000
	1914.				
5	Jan. 19	Ontario fine sandy loam. .	15,000,000	15,800,000	27,000,000
6	Jan. 19	Ontario fine sandy loam. .	14,500,000	15,000,000	22,000,000
7	Jan. 24	Dunkirk silty clay loam. .	22,000,000	13,000,000	25,000,000
8	Jan. 24	Dunkirk silty clay loam. .	39,000,000	16,500,000	48,000,000
9	Jan. 28	Dunkirk silty clay loam. .	70,000,000	35,000,000	‡60,000,000
10	Jan. 28	Dunkirk silty clay loam. .	36,000,000	18,000,000	56,000,000

* Counts upon asparaginate agar and upon soil-extract gelatin that are higher than the corresponding counts upon Lipman and Brown's agar are printed in bold-faced type.

† The medium used in making these counts contained only 0.05 per ct. asparaginate.

‡ This count is inexact because of rapid liquefaction.

colonies as does gelatin. With the exception of Lipman and Brown's agar, none of them have any advantage over the gelatin in the matter of definite chemical composition.

The same tables show how the counts obtained upon the asparaginate agar compare with those obtained upon the other four agar media. Fischer's agar gave a higher count than the asparaginate agar in five out of the seven tests listed in Table X, but in only four of the twelve tests included in Table XIII. Lipman and Brown's agar gave higher counts than the asparaginate agar in only four of the twenty-two tests included in Tables XI and XIII, and then always by a very narrow margin; while in several of the tests in which it has given a lower count than the asparaginate agar (as in the last

four tests of Table XI) the difference has been very pronounced. Brown's agar has given slightly higher counts than the asparaginate agar in three of the nine tests of Table XII, but in the other six tests has given much lower counts than the asparaginate agar; and in Table XIII has given higher counts than on the asparaginate agar in five of the twelve tests. Temple's agar has given higher counts than the asparaginate agar in six of the twelve tests listed in Table XIII. These counts show that the asparaginate agar is adapted to the growth of at least as large a number of soil bacteria as any of the other agar media; in this respect it is superior to them rather than inferior, and is unquestionably superior to Lipman and Brown's

TABLE XII.— TESTS OF BROWN'S CULTURE MEDIUM.

Test No.	Date.	SOIL TYPE.	BACTERIA PER GRAM DRY SOIL, AS DETERMINED WITH —		
			Asparaginate agar.	Brown's agar.	Soil-extract gelatin.
	1913.				
1	Sept. 24	Muck	*24,000,000	†13,000,000	29,000,000
2	Oct. 4	Ontario fine sandy loam	4,500,000	7,000,000	7,000,000
3	Oct. 8	Volusia silt loam	5,000,000	†8,000,000	8,700,000
4	Oct. 8	Volusia silt loam	5,000,000	†4,500,000	9,000,000
5	Oct. 8	Volusia silt loam	4,000,000	6,000,000	9,800,000
6	Oct. 22	Genesee loam	19,000,000	15,500,000	27,000,000
7	Nov. 20	Ontario fine sandy loam	‡20,000,000	14,000,000	27,000,000
8	Nov. 20	Ontario fine sandy loam	‡18,000,000	10,000,000	21,000,000
9	Dec. 15	Dunkirk silty clay loam	10,500,000	5,000,000	14,000,000

* Counts upon the asparaginate agar and upon soil-extract gelatin that are higher than the corresponding counts upon Brown's agar are printed in bold-faced type.

† In these cases there was such irregularity between the counts from the parallel plates that a satisfactory average could not be taken.

‡ The medium used in making these counts contained 0.2 per ct. asparaginate and only 0.05 per ct. dextrose.

agar. It has been found to allow much greater distinction in appearance between different kinds of colonies than Fischer's agar, slightly greater than Temple's, while it is certainly not inferior in this matter to Lipman and Brown's or to Brown's formula. In respect to definite chemical composition, as already stated, it is superior to all four.

Table XIII is of particular interest because all six of these media were included in this series of comparative tests. In these twelve tests there was very little variation between the counts obtained upon the different media. They do not even show the usual superi-

TABLE XIII.— TESTS COMPARING THE SIX CULTURE MEDIA DESCRIBED IN TABLE I.

Test No.	Date.	Soil Type.	Bacteria Per Gram Dry Soil, as Determined with —					
			Soil-extract gelatin.	Asparaginate agar.	Lipman and Brown's agar.	Fischer's agar.	Brown's agar.	Temple's agar.
	1914.							
1	Aug. 5	Volusia silt loam	9,500,000	8,000,000	5,500,000	6,700,000	8,000,000	*8,800,000
2	Aug. 5	Volusia silt loam	12,500,000	7,500,000	5,300,000	5,000,000	7,000,000	7,200,000
3	Aug. 6	Volusia silt loam	8,300,000	**†11,500,000**	**11,500,000**	**10,500,000**	**11,000,000**	**9,300,000**
4	Aug. 6	Volusia silt loam	10,000,000	**12,000,000**	8,800,000	**12,000,000**	**11,000,000**	**12,000,000**
5	Aug. 6	Volusia silt loam	9,500,000	6,700,000	6,000,000	*8,500,000	*8,300,000	*6,800,000
6	Aug. 7	Dunkirk silty clay loam	9,000,000	**14,500,000**	**14,000,000**	**11,800,000**	***15,000,000**	***15,000,000**
7	Aug. 7	Dunkirk silty clay loam	10,000,000	**11,000,000**	9,600,000	8,500,000	8,800,000	10,000,000
8	Aug. 8	Ontario loam	21,000,000	9,000,000	*13,000,000	*15,000,000	*14,000,000	*16,000,000
9	Aug. 8	Ontario loam	25,000,000	16,000,000	16,000,000	*21,000,000	*17,000,000	*20,000,000
10	Aug. 10	Volusia silt loam	5,000,000	**5,500,000**	**5,500,000**	**5,400,000**	**5,500,000**	5,000,000
11	Aug. 10	Volusia silt loam	8,500,000	7,000,000	6,600,000	5,800,000	5,200,000	6,700,000
12	Aug. 11	Volusia silt loam	10,500,000	6,000,000	*9,800,000	*9,000,000	*6,300,000	*7,000,000

* Counts on the last four media mentioned that are higher than the corresponding counts on asparaginate agar.
† Agar counts that are higher than the corresponding count on soil-extract gelatin are printed in bold-faced type.

ority of gelatin so far as count is concerned, as in only two tests (Nos. 8 and 9) was the gelatin count appreciably different from the agar counts. Sometimes one medium has given the highest count, sometimes another. None of them has given consistently lower counts than the asparaginate agar, with the possible exception of Lipman and Brown's medium, which has given a higher count only twice, and has equalled the asparaginate agar in count only three other times. These results, considered together with those listed in Table XI, give a particularly unfavorable showing to Lipman and Brown's agar, a fact which is important when it is remembered that this medium is the only one except the asparaginate agar that does not contain an appreciable amount of any substance of indefinite chemical composition. The differences between the various counts in Table XIII, however, are all too small to be of significance; and it must be concluded that under favorable conditions any one of these media (with the possible exception of Lipman and Brown's) is adapted to the growth of as many soil bacteria as any of the others. In choosing between them, the decision must be based upon other matters rather than upon the number of colonies they allow to develop.

Important considerations to be taken into account are these: A great drawback of Fischer's agar is that the colonies are all mere pin-points and cannot be distinguished from one another. A serious disadvantage of Lipman and Brown's medium and of Brown's modification of it is that molds and overgrowths are often so abundant upon them as to interfere with the counting and prevent the isolation of pure cultures from the colonies. A further objection to Brown's agar arises from the difficulty of obtaining an even distribution of the albumin, which must be added after the medium has cooled enough not to cause coagulation but before it is cold enough to prevent tubing. Temple's agar proves especially attractive to *Bacillus mycoides*, which was so abundant and vigorous in some of the soils studied as to overgrow the plates and to render counting difficult. Considering these points in addition to the advantages of the two new media that have already been discussed — the superiority of gelatin in the matter of allowing distinctions in appearance between different colonies, and of the asparaginate agar in the matter of definite composition — it must be concluded that the gelatin is the best medium for qualitative purposes, the asparaginate agar for quantitative work.

CONCLUSIONS.

Determinations of the number of bacteria present in soil are generally made by counting the colonies that develop on gelatin or agar media. Results depend largely upon the composition of the medium. Three important characteristics are to be looked

for in a medium for this purpose; it should allow the greatest possible number of soil bacteria to develop upon it, in order that the counts obtained may be as nearly correct as possible; it should allow the different kinds of bacteria to produce colonies as distinct as possible in appearance, in order to facilitate classification; and it should contain, as far as possible, no materials of unknown chemical formula, in order that different batches of the medium may be of the same chemical composition. In the past, these last two requirements have been almost overlooked.

In the course of the present investigation it has not been found possible to obtain a medium fulfilling all three of these requirements; but two new media have been tested out that are worth recommending. Both of these media fulfill the first requirement as well as any previously proposed medium. One of them, a soil-extract gelatin, fulfills the second requirement better than any of the other media proposed for soil work, and is therefore recommended for qualitative work. The other, an agar containing sodium asparaginate, fulfills the third requirement (except in so far as the agar itself is of indefinite composition) and is therefore recommended for quantitative work.

The soil-extract gelatin consists of gelatin, soil-extract and dextrose alone. This medium not only permits more ready classification of the colonies than any other medium tested, but also allows a larger number of colonies to develop than appear on the media ordinarily recommended for soil work. The soil-extract is not absolutely necessary, as practically as good results may be obtained when it is replaced with tap-water, and only slightly inferior results when distilled water is used in its stead. This gelatin medium is extremely satisfactory for qualitative work; and might also be recommended for quantitative work except for the indefinite composition of the gelatin itself.

The asparaginate agar contains no organic matter except the agar, dextrose and sodium asparaginate. Besides these materials, it contains several mineral salts. The formula given in this bulletin is not to be considered the best combination possible, although various proportions of the different chemicals have been tried without better success. Nearly as good quantitative results may be obtained by omitting the mineral salts and using tap-water instead of distilled water; but the colonies then are so small that this simplification is not to be recommended. The colonies developing on asparaginate agar are not so readily classified as those on gelatin, and the count obtained upon it is often lower, but its definite chemical composition makes it seem worth recommending for general use in quantitative work in soil bacteriology.

The media that have been compared with these are: Fischer's soil-extract agar; Temple's peptone agar; Lipman and Brown's

"synthetic agar" containing peptone, and Brown's modification of the latter in which the peptone is replaced by albumin. For qualitative work none of these media is as good as gelatin, but all of them except Fischer's allow some differences in appearance between the colonies of different kinds of bacteria. For quantitative work all four are about equally satisfactory; none of them give higher counts than the asparaginate agar.

Three points are brought out plainly by this investigation: (1) Gelatin media are not only better than agar media for qualitative work, but allow as many if not more of the soil bacteria to produce colonies. (2) A satisfactory agar medium can be prepared containing nothing of indefinite chemical composition except the agar itself. (3) This agar medium and those agar media especially recommended by Fischer, by Temple, by Lipman, and by Brown all give quantitative results so nearly alike that the counts obtained on any one of them may be compared with those obtained on any other, provided the same technique of incubation be used.

ACKNOWLEDGMENTS.

This work was begun while Dr. H. A. Harding was bacteriologist at this Station, and was completed under the direction of Dr. R. S. Breed, the present bacteriologist. Acknowledgments are due to them for the assistance they have given.

REPORT

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REPORT OF THE DEPARTMENT OF BOTANY.

DOES CRONARTIUM RIBICOLA OVER-WINTER ON THE CURRANT?*

F. C. STEWART AND W. H. RANKIN.

SUMMARY.

Currant felt-rust and white pine blister-rust are caused by the same fungus, *Cronartium ribicola,* in different stages of its life cycle. On account of repeated outbreaks of felt-rust on currants at Geneva unaccompanied, apparently, by the occurrence of blister-rust on pines in the vicinity, it was suspected that, contrary to accepted belief, the fungus may over-winter on currants. It is important to know if this be true, because of its bearing on the control of blister-rust. If true, the distribution of affected currant plants must be prohibited; if not true, there is no necessity for such restriction.

An attempt was made to solve the problem by transplanting diseased currant plants (after the leaves had fallen) into greenhouses and forcing them into growth during the winter. Through the cooperation of four other plant pathologists it has been possible to have such tests made in six greenhouses in as many widely separated localities. In four of the greenhouses there were made, also, attempts at inoculation by means of diseased currant leaves which had been wintered out-of-doors.

Although the total number of plants used in these experiments was about 500 and every one of them had been severely attacked by the felt-rust the previous autumn, no trace of Cronartium appeared on the new leaves. This leads to the conclusion that *C. ribicola* rarely, if ever, over-winters on currants. Hence, it is unnecessary to quarantine currants affected with felt-rust.

The recent discovery of two white pine trees affected with blister-rust makes it possible, now, to account for the outbreaks of currant felt-rust at Geneva without assuming that the fungus over-winters on currants.

* Reprint of Bulletin No. 374, February; for Popular Edition see p. 906.

PROBABLE LIFE HISTORY OF THE FUNGUS.

Cronartium ribicola is an heteroecious rust fungus, parasitic on Ribes and certain species of Pinus. In its aecial stage, which is known as *Peridermium strobi* Kleb., it attacks the trunk and branches of pine trees, producing a destructive disease called blister-rust. The species of Pinus attacked are, exclusively, those which bear their leaves in fascicles of five, the principal one being *Pinus strobus*, the white pine. In its uredinial and telial stages the fungus occurs on the leaves of various species of Ribes (currants and gooseberries), both wild and cultivated. On these hosts it is known as felt-rust and is of small economic importance.

The fungus is perennial in the bark of pine trees, but the aeciospores, produced in spring, are unable to infect other pines. Hence, the fungus cannot spread from pine to pine directly. It must first go to Ribes and then back to pine. The infection of Ribes leaves by aeciospores is followed, in from 10 to 21 days, by the appearance of uredinia and, later, by telia. During the summer and autumn the teliospores germinate *in situ*, producing promycelia which bear sporidia and these are blown about by the wind and may infect the pine host but not the Ribes. The urediniospores, on the other hand, infect Ribes leaves readily so that the fungus spreads rapidly from Ribes to Ribes during the summer and autumn; but since the leaves are the only part of the Ribes plant affected and the urediniospores are short lived, the career of the fungus on Ribes closes with the falling of the leaves in autumn. That is, the fungus cannot overwinter on Ribes. Such, in brief, is the life history of *Cronartium ribicola* as it is generally understood. However, several European mycologists have noted the occurrence of *C. ribicola* in localities where the alternate host appeared to be lacking, and Eriksson, at least, has expressed the opinion that it may live from year to year on currants, entirely independent of the aecial stage on Pinus.[1]

PUZZLING OUTBREAKS AT GENEVA.

The first outbreak of the fungus in America occurred on the Station grounds at Geneva in the autumn of 1906.[2] It was quite

[1] Eriksson, Jakob. Einige Beobachtungen über den stammbewohenden Kiefernblasenrost, seine Natur und Erscheinungsweise. *Centbl. Bakt.* [etc.] II., 2:377–394. 1896.

[2] Stewart, F. C. An outbreak of the European currant rust (*Cronartium ribicola* Dietr.) N. Y. (Geneva) Sta. Tech. Bul. 2. 1906.

severe. On some of the affected black currant plants nearly every leaf was thickly covered with rust. Outside the Station grounds only a single affected leaf was found. This led to the suspicion that the outbreak originated on the Station grounds. As the few five-leaved pines in the immediate vicinity of the Station appeared healthy, attention was directed to Eriksson's theory. It was suspected that the fungus had been introduced with some Ribes plants imported by the Station from England two years earlier. Accordingly, the entire plantation was dug up and burned in an attempt to eradicate the disease.

During 1907 and 1908 no trace of Cronartium was seen. In September, 1909, after a very thorough search, a single affected leaf of red currant was found in a plantation one-half mile west of the Station. During 1910 none was found.

In August, 1911, a second outbreak occurred on the Station grounds in a currant plantation set out in 1908 and 1909. These were all native plants. A few black currant plants were attacked severely and several varieties of red currants, also, showed some infection. This time the affected plants were not destroyed and no attempt was made to determine if neighboring plantations were affected.

In the autumn of 1912 there was an epidemic of the currant rust at Geneva. It occurred on black currants in nine nurseries and ten fruit gardens. In a nursery one-half mile north of the Station almost every leaf on 15,000 black currant plants was affected. One of the affected currant plantations was located about five miles southwest, another five miles northwest and a third about two miles northeast of the Station. These were the outposts of the disease. See Map 1.

During the six years intervening between the outbreaks of 1906 and 1912 the senior author had inspected, repeatedly, many pine trees in the vicinity in an attempt to locate the source of infection. Moreover, since 1909 the nursery inspectors located at Geneva had been constantly on the lookout for diseased pines. Nevertheless, none were discovered and the origin of the outbreaks of felt-rust remained a mystery. The failure to find any affected pines becomes more significant when it is stated that the number of five-leaved pines growing in the vicinity of Geneva is small. A few miles north of Geneva there is a large natural grove of white pine, but the fact

that black currants in the immediate vicinity of this grove were free from rust is proof that the source of the infection was not to be found there.

These recurring outbreaks of felt-rust on currants, seemingly without any relation to the aecial stage on the pine, made it appear highly probable that the fungus over-winters on currants as Eriksson has suggested. This is a matter of considerable importance. If the fungus over-winters on currants the disease may be spread through the distribution of affected plants by nurserymen. Accordingly, the writers undertook to solve the problem.

Spaulding[3] having suggested that the fungus may, perhaps, over-winter by the formation of uredinia on the young shoots we first made a careful examination of the buds and bark of a large number of diseased currant plants. Although every leaf on these plants was yellow with rust no sign of uredinia or telia was found either on the buds or the bark.

GREENHOUSE EXPERIMENTS.

The next attack on the problem was by means of a series of experiments in which affected plants, after being given a short period of rest, were placed in greenhouses, forced into growth, and the new leaves watched for the appearance of Cronartium. The plants used in these experiments were yearling black currant (*Ribes nigrum*) plants from a nursery near the Experiment Station. They had been under close observation for some time prior to the falling of the leaves and it is known that every plant had been abundantly infested with Cronartium. They were dug November 19, 1912. The few leaves still clinging to them were removed. Twelve of the plants were sent to Dr. J. C. Arthur, Lafayette, Ind.; 24 to Dr. G. E. Stone, Amherst, Mass.; 50 to Dr. G. P. Clinton, New Haven, Ct.; 200 to Dr. Perley Spaulding, Washington, D. C.; 100 to the junior author at Ithaca, N. Y.; and the remaining 100 were retained by the senior author for use at Geneva, N. Y.

Under date of May 23, 1913, Dr. Arthur reports as follows concerning the plants sent him: "The plants were left out-of-doors and subject to the changes of weather until February. They were then

[3] Spaulding, Perley. The blister rust of white pine. U. S. D. A. Bur. Pl. Indus. Bul. 206:31. 1911.

put into large pots in the cool greenhouse. They started up vigorously and made most abundant and normal growth. No rust has appeared on the plants up to the present time. They were kept under constant observation and a careful study was made to determine if the plants harbored any viable urediniospores. The work regarding the spores was in charge of Mr. Edward J. Petry, an instructor in the college and an unusually careful worker. He made an examination to ascertain if urediniospores were still harbored on the currant canes. It was assumed that they might be caught in the axils of buds and branches, on the scales or the fascicled bases of the stems. Several plants were carefully washed in order to secure all the spores which were attached. Eighty cubic centimeters of water was used at each washing and this was centrifuged in eight tubes. One-half cubic centimeter of sediment was taken from the bottom of each tube and placed on several young leaves which were carefully marked. This was repeated twice at different later stages of development of the leaves. No infection has occurred up to the present time. Mr. Petry made an estimate of the number of spores placed on the leaves as follows: 'From careful quantitative counts under the microscope, $\frac{1}{2}$ c. c. at the bottom of each tube contained 100 spores, i. e., 1/40 c. c. approximately was used in each count, and ten counts were made for one tube of each washing (which had been thoroughly shaken up before centrifuging). The counts of the spores ran from 2 to 7 spores, i. e., an average of 5 spores per count was found. This would make 5 x 20 ($\frac{1}{2}$ c. c.=20/40 of 1 c. c.) or 100 spores per $\frac{1}{2}$ c. c. This $\frac{1}{2}$ c. c. (containing probably 100 spores or more) was placed on 5 leaves so that each leaf should have received 20 spores and if these spores were at all viable, infection should have taken place. Some leaves were given $\frac{1}{2}$ c. c. in different drops, but neither these nor the others showed infection. In all, about 100 leaves were tried, but none showed signs of infection. From the above data, there must have been upwards of 2,500 spores in all these centrifugings.'

"I saw quite a number of slides from this centrifuge material. The urediniospores were abundant, but I saw none which appeared to me to be certainly viable. I am inclined to think from this work that if urediniospores remain thru the winter in condition to start infection the following spring it must be under exceptional circumstances. I am inclined to think that such result does happen occa-

sionally. I do not believe that the teliospores ever have any part in carrying the infection from currant over winter to the currant again.

"While this study, as we have conducted it, has been negative and shows quite clearly that under usual circumstances the rust is not propagated from year to year by the telia or uredinia, yet it does not preclude the possibility of the rust passing by means of the urediniospores from the currant to the currant again in the following season under certain favorable conditions. It does show, I think, that the rust, at least most strains of it, are not likely to persist long unless with the intervention of the white pine."

Dr. Spaulding reports as follows:

"The 200 *Ribes nigrum* bushes were received early in the winter. They were promptly heeled in and held thus until February 1st. On this date they were transferred to the experimental greenhouse. They started off new growth promptly and very vigorously, a very fine growth being obtained. Careful examinations were made of these bushes several different times to determine whether the fungus might be present upon them. The last examination was made about the middle of May. None of the disease was found at any time upon any of these bushes. About April 1st, I separated a few of the plants from the rest and inoculated them with teleutospore material received from you at that time. There were absolutely no results from these inoculations.

"In considering the results, it must be remembered that they are entirely negative and are subject to the same limitations as are any negative results. In my opinion, these results show that the disease is not often carried over upon dormant Ribes stock. I do not believe, however, the present series of experiments can be considered to have definitely shown that the fungus may not once in a great while thus be carried over; that is, there is still left the possibility of this occurring once in a large number of cases."

Dr. Clinton makes the following report on his experiments:

"Late in the fall of 1912 I received from Stewart of the Geneva (New York) Station, a number of black currants that had been badly infected with the pine-currant rust. These were heeled in out-of-doors, and left there until the last of February when twenty-nine

PLATE II.—SHOOT OF BLACK CURRANT AFFECTED WITH FELT-RUST.

The under surface of the leaves is thickly covered with the yellow, horn-like processes (telia) of the fungus.

(About two-thirds natural size.)

Plate III.—Trunk of White Pine Affected with Blister-rust.

One of the two diseased trees found at Geneva in May, 1913. The light areas on the bark are partly aecia of the fungus and partly masses of exuded resin.

(About one-fourth natural size.)

PLATE IV.—WHITE PINE TREE (No. 2) AFFECTED WITH BLISTER-RUST.
(About one-fourth natural size.)

were potted and placed in the greenhouse to force their foliage. About the middle of February sixteen plants were received from Stone of Amherst, these having been collected in an infected plantation in Massachusetts. These had been dug late in the fall and shipped soon afterwards, but by mistake had been sent to Storrs, so that by the time I received them they were beginning to leaf out. They were immediately placed in the greenhouse. All of these plants received from Stewart and Stone were kept in the greenhouse until late summer, examined from time to time, and no signs of the rust appeared on any of them. We still have some of them in the greenhouse at this date, January 1, 1914, but we have not seen the rust on any of these. It appears as if the rust did not carry over on this host through infections of the young perennial tissues the previous year. Certainly it does not commonly do so.

"I also received from Stewart some infected currant leaves which had been kept out-of-doors over winter, and in April I tried to infect young currant leaves from the III stage showing on these old leaves. This stage was not in good shape, indicating that its time for germination is in the fall rather than in the spring. As expected, I did not get any infection from this stage, as it is supposed to infect only the white pine."

Dr. Stone writes as follows concerning his experiments and observations in Massachusetts:

" For four or five years past the pine blister-rust has been found on imported stock in our Massachusetts nurseries, rarely if ever being found on native stock. During September, 1912, a specimen of currant rust was sent into the station from Ipswich, Mass., and this is apparently the first record of the rust in Massachusetts. At that date it was confined entirely to the black currants, variety Black Champion, of which there were four or five hundred bushes. None of the red currants were infected, and there were several acres of these growing with the black currants. One-fourth of a mile distant there was an older block of black currants which did not show the slightest infection.

"We received over three dozen infected black currant plants from Ipswich in the fall of 1912, and also two dozen from the Geneva Experiment Station. Some of each lot were transplanted directly into our greenhouse where the temperature maintained was 45° at

night. The remaining plants were heeled in out-of-doors until the first of February, when they were all transplanted beside the others.

"All the infected plants picked up very rapidly, developing good foliage, which remained green until December, 1913, or for more than one year, when most of them were taken out and thrown away. None had showed any indications of rusting during this time, and the few remaining bushes are free from rust at the present time (February, 1914). The plants which were put into the houses first without being heeled in were used in most cases for fumigation experiments.

"Careful inspection of the estate in Ipswich in 1913 showed that both the black and red currants were infected, the red currants suffering less than the others. Most of them were interplanted with apple trees and covered about thirty acres in blocks not far distant from one another. During the fall of 1912 inspection was made of the neighboring pines to see whether there was any rust, but none was noted. The past year, however, a number of pines near the infected currants have shown the rust, but this infection did not extend more than 100 yards from the currants. All of this infection is confined to imported white pines, no trace of infection being found on the native white pine. During 1913 six new locations, all in the eastern part of the state, were discovered for the currant rust, and in all thirty new pine infections. The state inspectors are doing everything possible to destroy infected material and establish a careful quarantine."

The 100 plants sent to Ithaca in the late autumn were heeled in out-of-doors until the second week of January when they were set out in benches in the greenhouse. They soon leafed out and grew vigorously. Careful observations were made for infections but none occurred. No attempt was made to inoculate the plants with wintered leaves. In May, after the finding of the two affected white pines at Geneva, inoculations were made by dusting the aeciospores from this material onto moistened Ribes leaves. The inoculated plants were covered with bell-jars and kept shaded for two days. Abundant infection resulted and the uredinia and telia were developed on almost every leaf of the 100 plants.

In the experiment at Geneva, 100 of the yearling black currant plants were placed in the greenhouse on December 2, but they did

not start into growth until about February 15. Their slowness in starting appears to have been due to their not having had a sufficiently long period of rest. However, once started, they made a vigorous, normal growth. They were kept under observation until May 7, but no Cronartium appeared upon them. Neither did any appear on the 12 black currant plants which Dr. Stone sent us from Ipswich, Mass. These latter were two-years-old plants which had been affected with Cronartium in the outbreak at Ipswich in the autumn of 1912.[4] They were planted in the greenhouse January 6, began to put out leaves January 28 and were under observation until April 17.

INOCULATION EXPERIMENTS AT GENEVA.

When it became evident that the Cronartium would not reappear, a series of inoculation experiments was undertaken with affected currant leaves wintered out-of-doors in wire cages. The previous autumn these leaves had been thickly covered with Cronartium which was mostly in the telial stage. They were brought into the laboratory, March 27, and allowed to dry. They were then ground into fine powder which was made into thin mush by stirring in a quantity of water.

Experiment No. 1.— On April 1 a quantity of the currant-leaf mush was applied to the leaves of four of the currant plants by means of a paint brush. The plants were small ones with new shoots 6 to 10 inches long and 20 to 30 leaves each. Every leaf was coated with the inoculating material on the upper surface and some, also, on the lower surface. After inoculation the plants were covered for 48 hours with bell-jars lined with moistened filter paper. During daylight the plants were shaded by covering the bell-jars with burlap. The leaves were damp all the time and during the last 24 hours most of them showed a row of water drops around the margin.

Experiment No. 2.— On April 4 four more plants were inoculated as in Experiment No. 1.

Experiment No. 3.— On April 7 four more plants were inoculated as in the preceding experiments except that the bell-jars were left over the plants for 72 hours. The leaves were still wet when the bell-jars were removed.

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[4] Stone, G. E. A new rust. Mass. Sta. Rpt. 25:41. 1913.

Experiment No. 4.— On April 10 four more plants were inoculated as in experiments Nos. 1 and 2.

Experiment No. 5.— On April 10 four potted plants were placed in a large glass inoculation-chamber and their leaves smeared with currant-leaf mush as in previous experiments. The air in the chamber was kept almost constantly at the point of saturation. Drops of water appeared on the margins of the leaves as in the bell-jar experiments. On April 16 these plants were reinoculated and kept moist for three days longer.

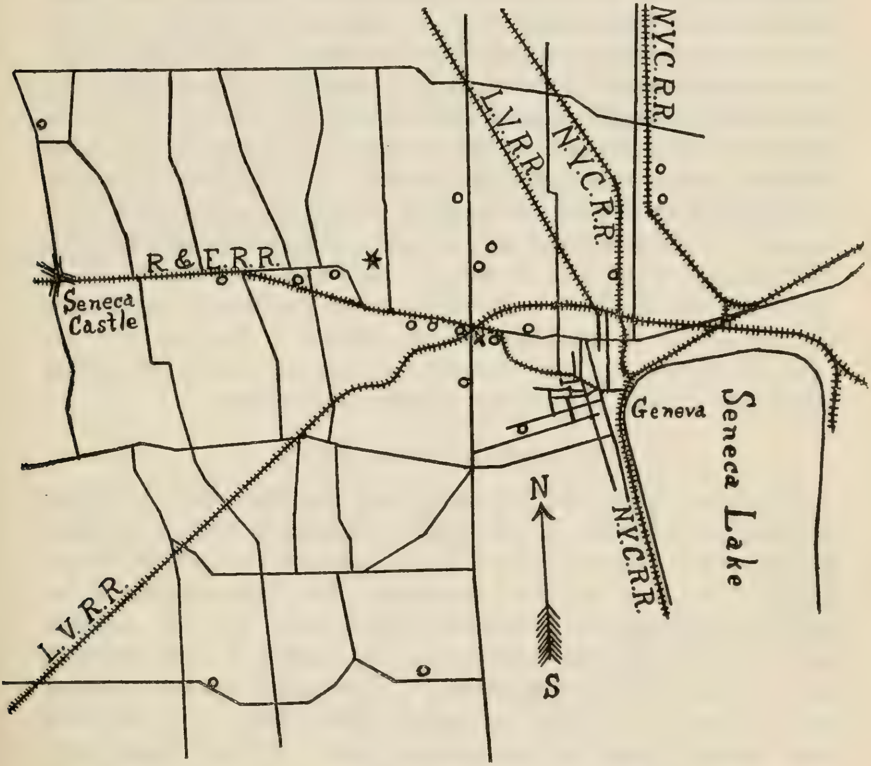
Up to May 7 no sign of Cronartium had appeared on any of the plants in the above experiments.

ORIGIN OF THE OUTBREAKS DISCOVERED.

All of the experiments having given negative results the origin of the outbreaks of currant rust became more obscure than ever. There seemed now to be but one thing to do, viz., to continue the search for affected pine trees. Early in May, 1913, the State nursery inspectors set out to examine every white pine tree in the vicinity of Geneva. On May 15, one of them, Mr. John Maney, reported that on the day previous he had discovered two white pine trees affected with blister-rust. Subsequently, his identification of the disease was fully verified. The affected trees were 9 or 10 feet high and about 15 years old. They were in a nursery about one mile west and one-half mile north of the Experiment Station. One of the trees (No. 1) was fairly vigorous and appeared not very much injured by the disease. It was attacked only on the trunk near the ground. A portion of the trunk, extending from the surface of the soil to a height of about seven inches, was thickly covered over about two-thirds of its circumference with conspicuous yellow aecia of *Peridermium strobi*. The trunk at this point was but slightly, if at all, enlarged.

Tree No. 2 stood about 120 feet from Tree No. 1. It was bushy and much distorted. Over a portion of the tree the needles were much browned. About 16 inches above the ground the trunk divided into three branches. Here was the seat of the trouble. Aecia were abundant on all of the branches and on the main trunk just below the crotch. A crotch canker had formed and borers were working in the diseased wood.

The two affected trees belonged to a lot of eight culls which had been left standing while the more desirable trees in the block had been dug and sold. Probably, they were imported trees although the owner is unable to furnish definite information on this point.



Map 1.—Distribution of *Cronartium ribicola* at Geneva in 1912 and 1913.

o = Ribes infection in 1912.
* = Pine and Ribes infection in 1913.
x = Experiment Station.

Scale, one inch = two miles.

From the fact that the point of attack was on the trunk near the ground it appears probable that they had been diseased ever since they were quite small.

Although diligent search was made no other diseased pines were found. These two trees may have been responsible for all of the

currant rust which has appeared at Geneva. They were cut down and burned on May 17.

About 120 feet south of the affected pine trees there was a small currant plantation containing both red and black currants. It was thought that the fungus might not have had a chance to infect these currants. For several days prior to May 15 the weather was dry and unfavorable for infection. The forenoon of May 15 was damp, but in the afternoon it dried off and remained dry until after the trees were destroyed. Thus it appears that the forenoon of May 15 was the only time when there was a chance for the currants to become infected. Nevertheless, infection occurred. A considerable number of uredinia were observed on June 10. Although both red and black currants in this plantation became quite abundantly infested with felt-rust and none were destroyed until about September 10, at which time the black currants were dug out and burned, the fungus did not spread to other currant plantations in the vicinity. Its failure to spread was due, probably, to the dry weather prevailing during the greater part of the summer and autumn.

DISCUSSION OF RESULTS.

The writers agree with Drs. Arthur and Spaulding that the results of these experiments do not prove conclusively that *Cronartium ribicola* never over-winters on Ribes. Negative results in experiments of this kind are never conclusive. Our interpretation of the results is that such over-wintering occurs rarely, if at all, and only under very exceptional conditions. The chances of over-wintering are so small that it is unnecessary to quarantine currants affected with felt-rust. The only precaution which needs to be taken is that affected plants are not shipped until after the leaves have fallen.

It may be argued that teliospores carried on or with affected currant plants may become a source of infection for pine trees; and because of this danger the distribution of affected currants should not be permitted. The writers consider that this objection is sufficiently answered by pointing out that the countless multitudes of teliospores which have been produced in the vicinity of Geneva during the past seven years have not infected a single pine tree so far as can be determined. However, if it seems that additional evidence is required it may be said that, normally, the teliospores

germinate only during the summer and autumn of the season in which they are produced; also, owing to the fact that the teliospores are never shed, it is improbable that they are carried, to any extent, on leafless plants.

Since the discovery of the two pine trees affected with blister-rust the outbreaks of currant rust at Geneva may be satisfactorily explained without assuming that the fungus over-winters on currants. Observations made during the epidemic of 1912 convince us that, in the uredinial stage, *Cronartium ribicola* readily spreads from one black currant plantation to another over distances of one-half mile. With this in mind it is easy to understand how, under favorable weather conditions, such an epidemic as that of 1912 may have originated with a single pair of diseased pine trees.

POTATO SPRAYING EXPERIMENTS AT RUSH IN 1913.*

F. C. STEWART.

SUMMARY.

During the summer of 1913 an extensive series of potato-spraying experiments was conducted in the vicinity of Rush, N. Y. In each of 66 fields a portion of one row (one-fiftieth acre) was very thoroughly sprayed by hand every two weeks. At digging time the yield of this row was compared with that of an adjacent row which had not received the special spraying. In 47 of the fields no spraying was done by the owner. In these fields the test was a comparison between very thorough spraying and no spraying. In the other 19 fields more or less spraying was done by the owner. In these, the test was a comparison between very thorough spraying and the kind of spraying done by the owner.

In the 47 unsprayed fields the spraying done by the Station increased the average yield by 17.76 bushels per acre, or 16.4 per ct.; and in the 19 sprayed fields, by 15.04 bushels per acre, or 11.2 per ct.

It is believed that the increase obtained was due to the partial control of tip-burn which was quite plentiful in some fields, the better control of Colorado potato beetles (not well controlled by the owner in a few cases), and stimulation of the plants. Late blight was entirely absent and early blight and flea beetles scarce. Probably, the gain from spraying would have been considerably larger had not the plants been killed prematurely by an early frost.

PRESENT PROBLEMS IN POTATO SPRAYING.

It pays to spray potatoes in New York. That has been conclusively proven by the numerous experiments made by this Station. Further experimentation along that line is unnecessary. Nevertheless, there is still something to be learned from potato spraying experiments. There is reason to believe that the present methods of spraying may be considerably improved. For one thing, it is probable that potato-growers would find it profitable to spray more thoroughly than they are now doing. Probably, lack of thoroughness is the chief fault of the present methods. Although some are spraying quite thoroughly, many New York potato-growers are

* Reprint of Bulletin No. 379, March; for Popular Edition see p. 918.

doing a very poor job with the spray outfit; and, worse yet, the majority, probably, are not spraying at all.

In the ten-year experiment on the Station grounds at Geneva five to seven very thorough sprayings increased the yield at the rate of 97.5 bushels per acre on the average. In the series of farmers' business experiments conducted during the last nine years of the same period the average increase in yield due to spraying was only 36.1 bushels per acre.* It appears that the better results obtained in the Station experiment were due, chiefly, to the thoroughness of the spraying. If so, it behooves farmers to spray more thoroughly. However, some hold that such spraying as was done in the Station experiments would not have increased the yield so much in farmers' fields. We think there may be some truth in this. Undoubtedly, the largest returns from spraying are to be obtained in fields in which the cultural conditions are favorable to large yields.

By means of the experiments reported in the present bulletin it was sought to obtain information on some of the points above mentioned. An attempt was made to find out what thorough spraying will accomplish in farmers' fields. To be more explicit, the objects of the experiments were three:

(1) To determine how much the yield in farmers' fields may be increased by very thorough spraying;

(2) To determine how efficient are the spraying methods now employed by farmers;

(3) To furnish object lessons for farmers in their own fields.

THE EXPERIMENTS.

Rush was selected as the location of the experiments chiefly for two reasons: (1) Because potatoes are grown extensively there; and (2) because we were able to secure there a suitable man to do the spraying, viz., Mr. H. F. Keyes, a student in the New York State College of Agriculture, who performed the work during his summer vacation. In June, Mr. Keyes visited potato-growers in the vicinity and secured permission to spray a portion of one row (290.4 feet long) in each of 66 fields. After the potatoes came up a careful selection of rows was made and the portion to be sprayed marked at both ends by means of stakes driven in the ground. In the selection of these rows care was taken to avoid dead-furrows, back-

* Bulletin No. 349 of this Station.

furrows and soil inequalities. Spraying was commenced when the plants were six to eight inches high and repeated at intervals of two weeks until frost, which occurred on September 14. At this time the rows in the early-planted fields had received six sprayings and those in the later-planted fields five sprayings. All spraying was done very thoroughly by means of a knapsack sprayer. The first two applications were made with bordeaux mixture containing four pounds of copper sulphate (and sufficient lime to neutralize it, as shown by the potassium ferrocyanide test) to each fifty gallons. Paris green was added at the rate of one pound to fifty gallons. Subsequent applications were made with bordeaux mixture, alone, in which the quantity of copper sulphate was six pounds to fifty gallons. The supply of bordeaux for each day's work was carried in a barrel fastened on the rear of a one-horse buggy which was driven from field to field as needed. In 47 of the fields containing experiments the owner used no bordeaux, but applied only such treatment as he considered necessary for the control of bugs. In the remaining 19 fields more or less bordeaux was applied by the owner, the number of applications in different cases varying from one to eight (see Table II) and there were no unsprayed rows; that is to say, in these fields the spraying done by the Station was in addition to that done by the owner. If the owner sprayed three times and the Station six times the plants on the Station row received a total of nine sprayings.

The season was a very dry one and there was no late blight (*Phytophthora infestans*) in any of the fields, not even on unsprayed plants. Neither was there early blight (*Alternaria solani*) of any consequence, nor serious damage done by flea beetles. But in nearly all fields there was more or less tip-burn which, in some cases, was quite severe. "Bugs" were moderately plentiful. In a few fields they were not fully controlled by the treatment employed by the owner.

A killing frost occurred on the night of September 14. At this time the plants in most of the fields were in nearly full foliage. As 51 of the fields had been planted after June 1, and many of them between June 10 and 17, this untimely frost cut off from two to four weeks of growth and thereby lowered the yield considerably.

At digging time the row sprayed by the Station and an adjacent row of equal length were dug by hand and the product sorted and weighed. This work was all done by Mr. Keyes. The yields are shown in Tables I and II.

Table I.—Results of Thorough Spraying of Single Rows in Forty-seven Unsprayed Potato Fields.

Owner's Name.	Unsprayed.			Sprayed by the Station.				Increase per acre due to spraying.
	Yield per row.		Yield per acre; marketable tubers.*	Times sprayed.	Yield per row.		Yield per acre; marketable tubers.	
	Marketable tubers.	Culls.			Marketable tubers.	Culls.		
	Lbs.	*Lbs.*	*Bu.*		*Lbs.*	*Lbs.*	*Bu.*	*Bu.*
M. Perry	98	10	81.7	5	172	3	143.3	61.6
F. O. Todd	152	0	126.7	5	205	0	170.8	44.1
Wm. Fagan	30	12	25	5	80	8	66.7	41.7
F. Hinderland	151	4	125.8	5	201	3	167.3	41.5
Roy Dunn	134	4	111.7	5	180	3	150	38.3
Mrs. F. Lonthair	92	0	76.7	5	136	0	113.3	36.6
John Remelt	154	4	128.3	6	194	4	161.7	33.4
R. Fielder	150	0	125	5	189	0	157.5	32.5
Jas. McNall	114	3	95	5	153	5	127.5	32.5
R. Laidlan	177	0	147.5	6	215	0	179.2	31.7
J. Burmeister	90	4	75	5	126	5	105	30
L. Loss	100	3	83.3	5	135	3	112.5	29.2
J. Fagan	124	7	103.3	6	158	18	131.7	28.4
H. E. Benedict (1)	218	0	181.7	5	250	0	208.3	26.6
Geo. Bean	151	0	125.8	5	181	0	150.8	25
F. Howlett	130	5	108.3	5	160	5	133.3	25
Frank Stanton	132	0	110	5	162	0	135	25
R. A. Keyes	118	3	98.3	6	146	3	121.7	23.4
L. H. Bemis	192	0	160	5	216	0	180	20
Jay Green	186	0	155	5	210	0	175	20
E. G. Darrohn	115	0	95.8	5	138	0	115	19.2
W. J. Kirkpatrick	70	3	58.3	5	92	5	76.7	18.4
T. Maloney	99	4	82.5	6	120	4	100	17.5
J. E. Christ	180	0	150	5	199	0	165.8	15.8
Mrs. F. Gardner	78	3	65	5	95	3	79.2	14.2
J. Gutschau	160	0	133.3	5	176	0	146.7	13.4
M. Moran	74	3	61.7	5	90	5	75	13.3
L. Wagner	111	0	92.5	5	127	0	105.8	13.3
A. Cummins	164	7	137	6	180	3	150	13
John Heech	198	0	165	5	212	0	176.7	11.7
J. Darrohn (1)	141	0	117.5	5	154	0	128.3	10.8
E. Green	109	7	90.8	5	121	5	100.8	10
F. C. Long	95	0	79.2	5	107	0	89.2	10
J. Leyden	99	3	82.5	5	111	3	92.5	10
D. Maher	77	2	64.2	5	89	2	74.2	10
Geo. Allen	90	0	75	5	100	0	83.3	8.3
F. A. Sheldon	110	3	91.7	5	120	5	100	8.3
Wm. Spatsker	168	3	140	5	174	3	145	5
R. Shoemaker	105	3	87.5	5	108	3	90	2.5
A. Keafer	162	4	135	5	163	3	136	1
H. M. Van Voorhis	231	0	192.5	6	232	0	193.3	0.8
Chas. Post	72	3	60	5	72	3	60	0
J. Darrohn (2)	108	10	90	5	105	14	87.5	†—2.5
W. Rotherick	100	3	83.3	5	96	3	80	—3.3
Chas. O'Brien	126	0	105	5	120	0	100	—5
Paul Martin	129	7	107.5	5	120	6	100	—7.5
W. Markham	240	0	200	5	216	0	180	—20

* A row 290.4 x 3 ft. = one-fiftieth acre. In some fields the rows were less than 3 feet apart. Nevertheless, in the computation of the acre yields given in Tables I and II the area of a row is assumed to be one-fiftieth acre in all cases. † A minus sign indicates reduced yield.

Average yield of unsprayed rows, 108.23 *bu. per acre.*
Average yield of the rows sprayed by the Station, 126 *bu. per acre.*
Average increase in yield per acre, 17.76 *bu., or* 16.4 *per ct.*

TABLE II.—RESULTS OF THOROUGH SPRAYING OF SINGLE ROWS IN NINETEEN SPRAYED POTATO FIELDS.

Owner's Name.	Sprayed Only by Owner.				Sprayed Also by Station.				Increase per acre due to extra spraying by Station.
	Times sprayed.	Yield per row. Marketable tubers.	Yield per row. Culls.	Yield per acre; marketable tubers.	Times sprayed by Station.	Yield per row. Marketable tubers.	Yield per row. Culls.	Yield per acre; marketable tubers.	
		Lbs.	*Lbs.*	*Bu.*		*Lbs.*	*Lbs.*	*Bu.*	*Bu.*
F. L. Martin......	3	136	2	113.3	5	193	3	160.8	47.5
W. Perry..........	3	138	0	115	6	179	0	149.2	34.2
David Dell........	8	140	0	116.7	5	180	0	150	33.3
W. A. Keyes (1)...	7	126	3	105	6	162	4	135	30
G. J. McNall.....	1	121	0	100.8	5	152	0	126.7	25.9
C. Schwartz.......	2	90	5	75	5	120	7	100	25
C. A. Search......	2	186	0	155	5	215	0	179.2	24.2
D. Harrington....	1	191	0	159.2	5	211	0	175.8	16.6
Norris Bros.......	7	248	0	206.7	6	266	0	221.7	15
A. White..........	4	139	11	115.8	5	157	11	130.8	15
F. Rath...........	5	101	7	84.2	5	116	7	96.7	12.5
C. Diver..........	1	180	0	150	5	191	0	159.2	9.2
B. H. Diver.......	1	190	3	158.3	5	200	3	166.7	8.4
Frank Chase.......	5	217	0	180.8	5	224	0	186.7	5.9
D. S. McNall.....	4	146	3	121.7	5	149	3	124.2	2.5
H. E. Benedict (2).	1	240	0	200	5	240	0	200	0
M. Harrigan.......	1	141	3	117.5	5	139	3	115.8	—1.7
W. A. Keyes (2)...	6	141	7	117.5	5	133	7	110.8	—6.7
P. F. Martin......	6	200	0	166.7	5	187	0	155.8	—10.9

Average yield of rows sprayed only by owner, 134.7 *bu. per acre.*
Average yield of rows sprayed also by the Station, 149.74 *bu. per acre.*
Average increase in yield per acre, 15.04 *bu., or* 11.2 *per ct.*

COMMENTS ON THE RESULTS.

The increase in yield due to spraying was small compared with that usually obtained by very thorough spraying. However, it is as large as could be reasonably expected when it is considered that the conditions were extremely unfavorable. In dry seasons when there is little or no blight the increase in yield from spraying is largely dependent upon the fact that sprayed plants live considerably

longer than unsprayed ones. In the present case this advantage of prolonged growth was lost through the killing of the plants by an early frost. It appears that the increase obtained was due to the partial control of tip-burn, the better control of "bugs" (in a few cases) and the imperfectly-understood stimulation effect of the bordeaux.

In experimental work of this kind the experimental error is certainly large for individual experiments, though for an average of forty-seven experiments it is probably small. That is to say, we believe that the average increase from thorough spraying was, actually, between 17 and 18 bushels per acre as shown by the results of the experiments, notwithstanding the fact that in certain of the experiments there was an unaccountable reduction in yield. In five of the experiments the row very thoroughly sprayed by the Station yielded less than the unsprayed check row adjacent and in three other experiments (in sprayed fields) the extra spraying done by the Station apparently decreased the yield.

There is no reason, whatever, for believing that spraying was harmful in these eight experiments. Undoubtedly, the true explanation is that the check row possessed some advantage over the Station row and would have outyielded it still more if neither row had been sprayed. In one case (J. Darrohn's experiment) an explanation was found in the fact that the check row contained 21 more hills than the Station row; but what was the cause of the erratic results in the other seven experiments is unknown.

If the reduction in yield in these eight experiments is ascribed to original inequalities between the test rows it must be admitted that similar inequalities existed in some of the experiments showing increased yield from spraying. It is doubtless true that, in some of the experiments, the increase in yield apparently due to spraying was, in reality, partly due to other causes. However, by averaging the results of a large number of experiments the probability of error is greatly diminished.

The average gain from the spraying done by the Station was nearly as large in sprayed fields as in unsprayed ones, being 15.04 bushels per acre in the former and 17.76 bushels per acre in the latter. If these figures are reliable, they indicate that the spraying done by the owners was of small value; but it should be considered that the number of experiments in sprayed fields was rather small — only

nineteen. In the experiment of David Dell (the only one in which an unsprayed row was left in a sprayed field) the Station row outyielded the owner's row by 33.3 bushels per acre, while the unsprayed row yielded 16.7 bushels per acre less than the owner's row. Mr. Dell sprayed eight times.

Of the sixty-six fields in which these experiments were conducted, only nineteen, or less than one-third, were sprayed by the owner; and of the nineteen sprayed fields certainly not more than nine were properly sprayed. Probably, this represents fairly well the present status of potato spraying at Rush. It is very evident that potato-growers here are still unconvinced that it pays to spray potatoes. If all the summers were like that of 1913 such a view might be justified, but they are not. Another season's experiments may show spraying in a very different light. It is expected that the experiments will be repeated during the coming season.

DEAD-ARM DISEASE OF GRAPES.*

DONALD REDDICK.†

SUMMARY.

The dead-arm disease of grapes occurs in the majority of vineyards of the State, where it takes an annual toll from the income of the vineyardist. The most striking symptoms of the disease are the presence of bare arms in the spring and the occurrence of dwarfed, crinkled, yellowish-colored leaves during the early part of the growing season.

The cause of the disease has been determined to be the fungus, ***Cryptosporella viticola.*** The fungus has been studied and its pathogenicity established by numerous inoculation experiments. Infection of new shoots occurs from spores produced in the fruiting bodies of the fungus which develop on tissue killed the previous year. Preserving infected canes for bearing wood is thought to be the chief means by which the fungus gains entrance into the arms and trunk. The fungus rarely passes down the trunk to subterranean parts.

The chief method of control lies in marking and removing all vines showing symptoms of the disease. Suckers originating from beneath the surface of the ground almost invariably develop strong and vigorous vines unless infected by spores during the first few weeks of their development. Those originating above the surface of the ground develop healthy plants unless the fungus has grown down the old trunk to the point of issuance of the shoot in which case the renewal usually dies in its second or third year.

INTRODUCTION.

In a bulletin of the Cornell University Agricultural Experiment Station (No. 263, February, 1909), the writer[1] published a pre-

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* Reprint of Bulletin No. 389, July; for Popular Edition see p. 953.

† Formerly Assistant Botanist of this Station, connected with Chautauqua Grape Culture Investigations; now Professor of Plant Pathology, Cornell University.

[1] For this and similar references to literature, see Bibliography, p. 277.

liminary report on a destructive disease of grapes, entitled Necrosis of the Grape Vine. At the time of publication of that bulletin it was realized that there were many points yet to be studied. Among these should be mentioned, first of all, the absence of inoculation experiments which would prove absolutely that the fungus found constantly associated with the disease was really the primary cause of it and not a secondary factor incidental to some other disorder. A more extended survey of the distribution of the disease in the vineyard regions of the State and a more intensive study of its occurrence in individual vineyards seemed important. Careful observations and experiments were necessary on the method by which the disease spreads. This seemed particularly true with respect to the possibility of spread of the disease through affected nursery stock. Finally, control experiments based upon the above findings were of utmost practical importance.

Through opportunity to work at the vineyard laboratory of the Station during the summers of 1909 and 1910 a number of these points have been cleared up and a satisfactory report of progress of the investigations can now be made. Although this report is intended primarily to supplement and extend the work reported in the Cornell bulletin, certain portions of the information recorded there is repeated inasmuch as the edition of that bulletin is exhausted.

THE DISEASE.

NAME.

The name most commonly applied to this disease is dead-arm or side-arm disease. The writer undertook to introduce the name necrosis, which still appeals to him as a good name for this type of disease, but unfortunately he was not aware, until the fact was pointed out, in 1911, by Dr. Shear, of the United States Department of Agriculture, that this name had already been used by Cavara (1897) to designate a bacterial disease of the grape occurring in Europe, said to be caused by *Bacillus vitivorus*. It therefore seems advisable to go back to the well-established name of dead-arm disease.

OCCURRENCE.

The disease occurs on practically every variety of the grape grown commercially in the State. Naturally it is most frequently met with

on the more important commercial varieties. Delaware seems to have a certain amount of resistance, at least the disease has rarely been found on that variety. The variety Pocklington seems to be particularly susceptible, but as this variety is not grown extensively, data on this point are difficult to obtain.

DISTRIBUTION.

So far as the writer's observations go, no district in the State is free from the disease, nor does there seem to be any great difference in the prevalence of the disease in the different districts. The writer has rarely visited a vineyard in the State in which at least occasional diseased vines could not be found. Perhaps the least of the disease is to be found in the Keuka Lake region. This is only a general impression as no accurate estimates of percentages of diseased vines have ever been made in this section.

The observations of Shear (1911) extend the known distribution of the disease to practically all the vine-growing sections of the eastern United States. Lately Bubák (1911) has reported a vine disease occurring in Hungary the cause of which is described as a fungus closely related to the causal organism of the dead-arm disease. Since no such disease has been reported either from France or Germany it seems quite evident that the disease is indigenous to America and apparently confined to it at the present time.

LOSSES.

The insidious nature of this disease makes a determination of its extent and destructiveness almost impossible. One may mark 1 per ct., 2 per ct., or occasionally 5 per ct. of diseased vines in a vineyard at a single inspection. Sometimes as many more can be marked the following year. How long this might continue remains to be seen.

The loss, of course, is considerable. Besides the dead vines there are many others declining in vitality which each year bear fewer and fewer pounds of grapes until finally they die or are removed.

SYMPTOMS.

(a) The dead arm is the most strikingly obvious symptom of the disease. Fig. 5 (Plate VI). Almost as frequently the entire vine dies, in which case suckers usually spring up about the base.

(b) Another striking symptom, but visible only in June and early July, is the peculiar yellow coloration of the foliage and the dwarfing, crimping, and curling of the leaves. Fig. 4 (Plate V). As the season advances the yellow color usually disappears, but the small crimped leaves still persist. The grower is sometimes deluded into believing that his vines have grown out of the disease. Careful examination the next year, however, will show that the vine is either dead or in a much more weakened condition.

FIG. 6.—LONGITUDINAL SECTION OF TRUNK AND ARM OF VINE SHOWN IN PLATE II.
(Position of arms reversed.)

(c) Vines are apt to die at any time of the year although most of them seem to die in the winter. Presumably their feeble growth of the preceding summer makes them very susceptible to injury by frost and cold. Fig. 6. It is not unusual, however, to find a vine wilting in midsummer.

(d) In certain instances one may find peculiar longitudinal ribbed excrescences on the trunk or arm. The excrescence is not tuberculate as in the case of crown gall, and it does not possess the fleshy consistency of a crown gall tumor. Nor does the excrescence have the appearance or consistency of the hard tuberculous outgrowth which follows winter injury.[2]

[2] Particular mention is made of these facts because they correct certain mistakes of the former bulletin. The vine shown in Cornell Bulletin 263, fig. 45, is attacked by crown gall as well as dead arm, and the lesions shown in this figure and in figure 46 are caused by the crown gall organism, *B. tumefaciens*. The lesion shown in figure 47 is probably of similar origin, as it came from a vineyard in which practically all the vines are infected. When in the vineyard on July 21, 1909, very evident lesions of the dead-arm disease were found on two shoots.

(e) A dry rot in the heart of the trunk and usually extending to the margin is more or less characteristic. (Fig. 7.)


Fig. 7.—Cross Sections of Diseased Niagara Trunks Showing Characteristic Necrotic Effect.

(f) The small reddish brown or black spots on the green shoots, petioles, peduncles, and leaf veins are very characteristic. Sometimes they are deep and the shoot shows narrow V-shaped slits; at other times the spots are more superficial but are so numerous as to make a continuous diseased area for some distance on the shoot. In very severe cases the lesions are deeper and the V-shaped slits mentioned above extend for some distance, usually from one to three inches, up and down the shoot. Fig. 5 (Plate VII). These lesions are discernible the following spring as reddish elevations, or as a noticeable longitudinal cracking or stringing of the fibres.

(g) The occurrence of the disease on ripe or nearly ripened berries has been found repeatedly on Niagara grapes at Romulus, N. Y., by Mr. C. T. Gregory (1913). The disease is scarcely distinguishable from black rot except on very careful examination. Usually it is necessary to use the microscope to confirm a diagnosis with any degree of certainty. The berry shrivels (Fig. 6—Plate VII) to a mummy as in the case of black rot but has a slightly more grayish appearance and the pustules which occur so thickly over the surface of a black-rot berry are more scattered in the case of this rot.

ETIOLOGY.

The cause of this disease is a fungous parasite technically known as *Cryptosporella viticola* Shear. The fungus was apparently first

Isolations made from an old arm near the first wire of the vine shown in figure 45 and from various places in and above the lesion shown in figure 47 gave numerous pure cultures of the causal organism of dead arm. The vine in figure 45 has been visited every year since the photograph was taken. In July, 1910, some of the shoots showed evident lesions of the dead-arm fungus. In 1912 the vine bore a good crop of fruit although the lesions of crown gall were about as abundant as in the photograph.

EXPLANATION OF PLATES AND FIGURES.

FIG. 4. (PLATE V) — CONCORD VINE IN LAST STAGES OF DEAD-ARM DISEASE.
One arm apparently missing for several years.
(No. 3227. Fredonia, N. Y., June 21, 1909.)

FIG. 5. (PLATE VI) — CHARACTERISTIC APPEARANCE OF VINE AFFECTED WITH DEAD-ARM DISEASE.
The small blanched and crinkled leaves on the cane at the left are typical. Some leaves on arm at right not full size and some blanched about the margins. Arm at right would have died during the summer or succeeding winter. A longitudinal section of trunk and arms is shown in Fig. 6.
(No. 3226. Fredonia, N. Y. Photograph made June 24, 1909.)

FIG. 6. LONGITUDINAL SECTION OF TRUNK AND ARM OF VINE SHOWN IN PLATE VI.
Position of arms reversed. Trunk diseased for several years as shown by extent of diseased (dark) area. Relatively small amount of healthy conducting tissue of interest as is fact that tissue below surface of the ground is healthy. (Figure on p. 254.)

FIG. 7. CROSS SECTIONS OF DISEASED NIAGARA TRUNK SHOWING CHARACTERISTIC NECROTIC EFFECT. (Figure on page 255.)
(Natural size. Photograph made Oct. 26, 1908.)

PLATE VII, FIG. 5 — LESIONS OF DEAD-ARM FUNGUS ON SHOOTS.
Probably from infection of May 28, 1909. Various degrees of infection shown. Shoot at bottom infected at so many points that lesions fused to form continuous blackened area. Longitudinal splitting evident in some cases.
(No. 3240. Worden. Romulus, N. Y. Photograph made Aug. 2, 1909, by C. N. Jensen.)

PLATE VII, FIG. 6 — ROT OF BERRIES CAUSED BY DEAD-ARM FUNGUS.
Earlier stages (upper left in plate) center about lenticels, differing from black rot in that respect as well as in general appearance. Later stages can scarcely be distinguished from black rot except by microscopic examination.
(No. 6118. Niagara. Romulus, N. Y. Photographs made Oct. 8, 1912, by C. T. Gregory.)

PLATE VII, FIG. 7 — LESIONS OF ANTHRACNOSE DISEASE ON SHOOTS AND BERRIES.
Anthracnose and the dead-arm disease confused by some although lesions are very different. Most conspicuous difference in case of anthracnose, which, on shoots, is usually noticeably elevated.
(Vergennes. Portland, N. Y. Photographs made July 24, 1909.)

FIG. 8. PERITHECIAL STROMATA OF *Cryptosporella viticola.*
(Found and illustrated by Shear.)

(*Explanations continued on page following plates.*)

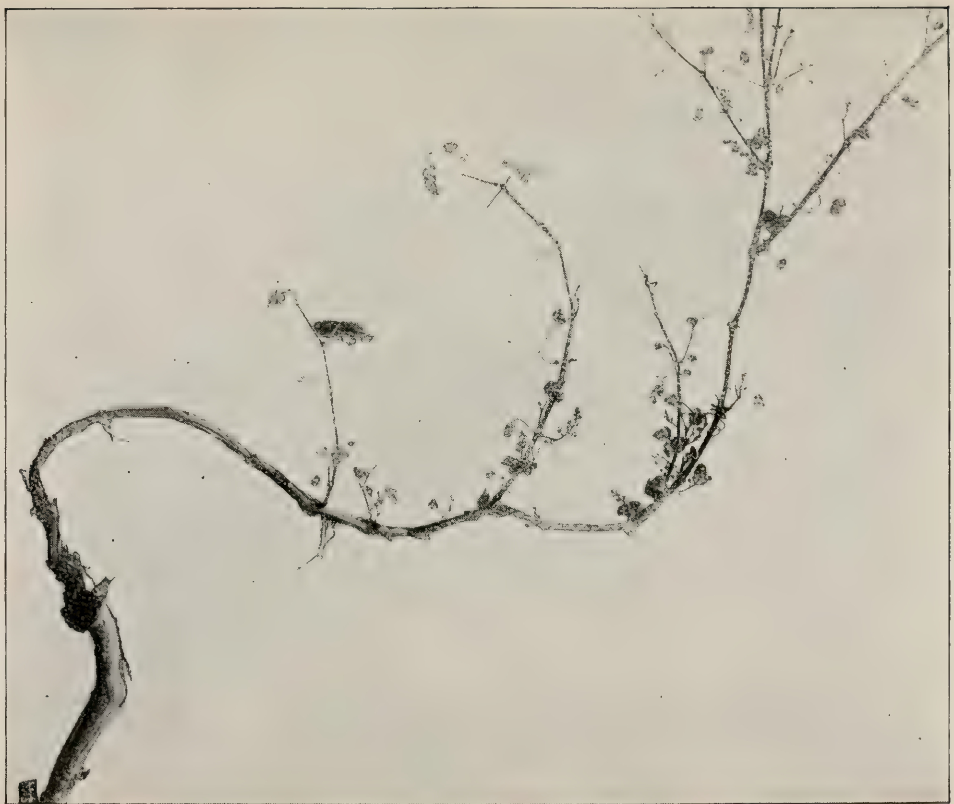


Plate V.—Concord Vine in Last Stages of Dead-arm Disease.

PLATE VI.—CHARACTERISTIC APPEARANCE OF VINE AFFECTED WITH DEAD-ARM DISEASE.

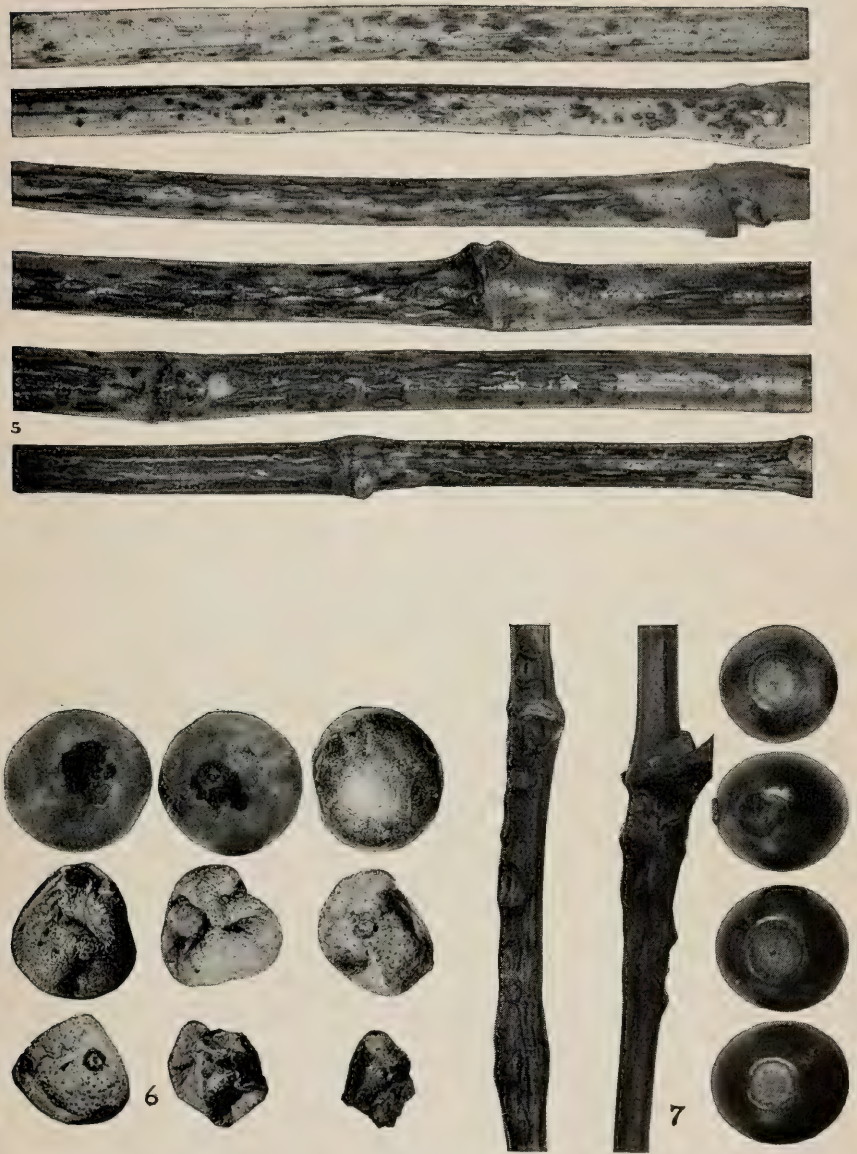


PLATE VII.

5, Lesions of dead-arm fungus on shoots.
6, Rot of berries caused by dead-arm fungus
7, Lesions of anthracnose disease on berries and shoots.

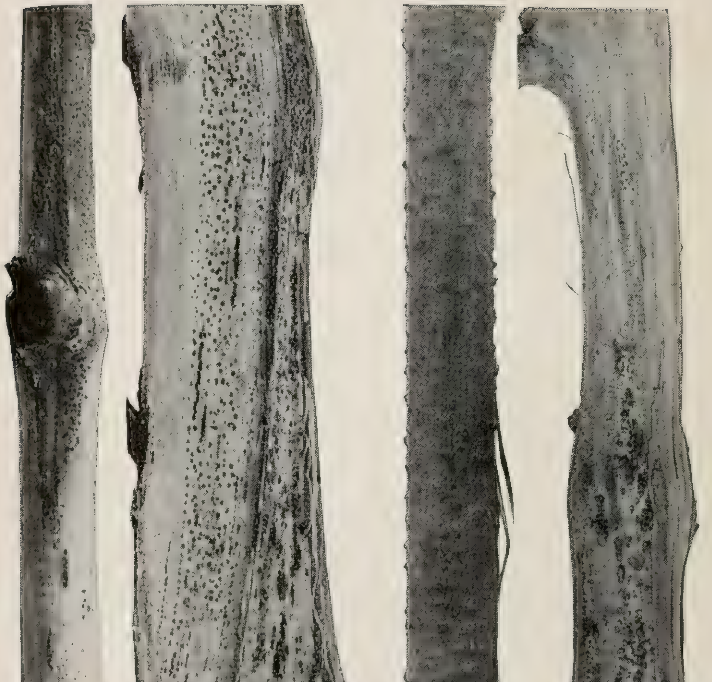
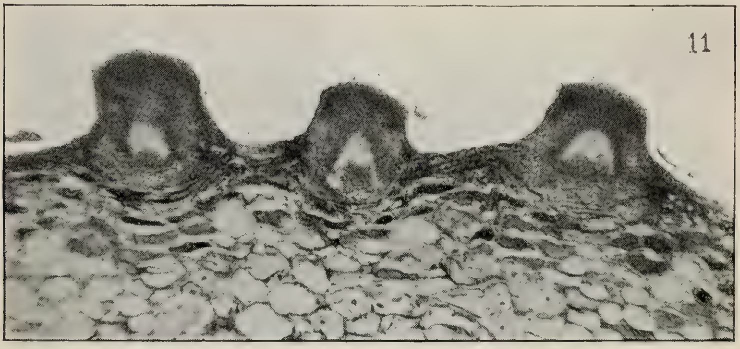


Plate VIII.— Pycnidia of *C. viticola*



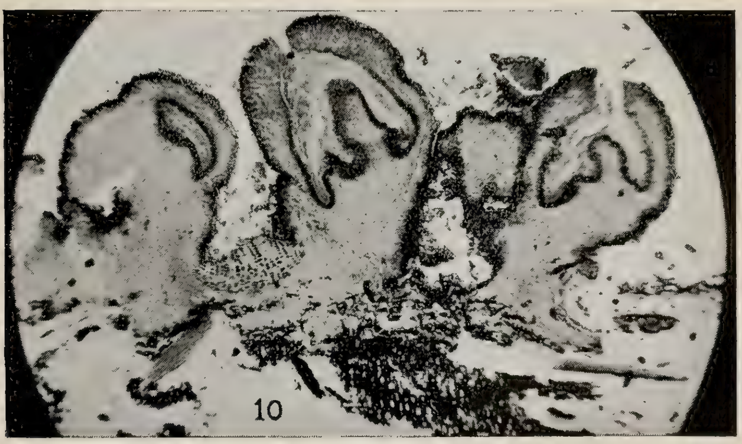


PLATE IX.
(See page 469 for explanation.)

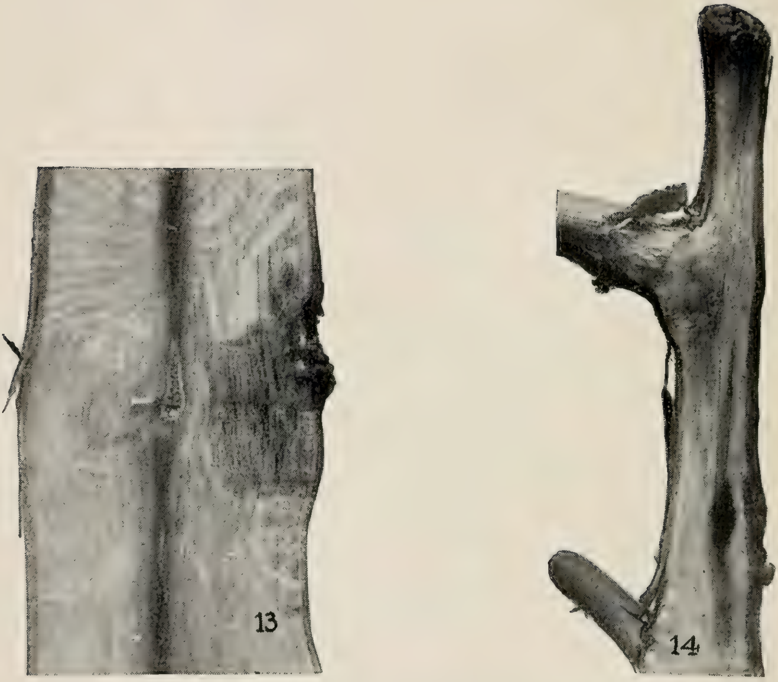


Plate X.— Artificial Infection on Trunk (13) and Cane (14) of Worden Vine.

FIG. 9. (PLATE VIII) — PYCNIDIA OF *Cryptosporella viticola.*

A. On Concord cane.

(No. 3232. Lamberton, N. Y. Aug. 10, 1909.)

B. On Niagara trunk.

No. 3225. Romulus, N. Y. June 9, 1909.)

C. On Worden cutting, causing its death.

(Twice natural size. Photograph made July 10, 1910.)

D. On Concord arm.

(No. 2983. Westfield, N. Y. Collected and photographed May 1, 1904, by H. H. Whetzel.)

FIG. 10. (PLATE IX) — PHOTOMICROGRAPH OF PYCNIDIA ON TRUNK OF CONCORD VINE SHOWING RELATIVE POSITION.

The cavity in such pycnidia is usually much convoluted.

FIG. 11. (PLATE IX) — PHOTOMICROGRAPH OF THREE PYCNIDIA IN A ROTTEN BERRY SHOWING RELATIVE POSITION.

Pycnidia on the fruit are usually simple.

FIG. 12. (PLATE IX) — DRAWING OF CROSS-SECTION OF SIMPLE PYCNIDIUM FROM FRUIT OF NIAGARA GRAPE.

Spore-bearing area only partially filled in. Both pycnospores and scolecospores are shown.

(Outlined with aid of camera lucida from stained section, by C. T. Gregory.)

FIG. 13. (PLATE X) — ARTIFICIAL INFECTION ON TRUNK OF WORDEN VINE.

Inoculation made July 12, 1909. Point of inoculation may be seen near margin.

Infection has occurred but fungus has not spread rapidly.

(No. 3229. Photograph made July 19, 1910.)

FIG. 14. (PLATE X) — ARTIFICIAL INFECTION ON CANE OF WORDEN VINE.

Inoculation made July 9, 1909.

(No. 3216. Photograph made Sept. 24, 1710.)

described by the writer (1909) as one new to science. It was found and described only in its imperfect stage and was called *Fusicoccum viticolum*. Since that time Shear (1911) has found the ascosporic or so-called perfect stage. He finds it to be one of the genus Cryptosporella and calls it *C. viticola*.

LIFE HISTORY OF FUNGUS.

Perithecia.— The Cryptosporella stage of the fungus has been reported by Shear from Michigan, Virginia, and New Jersey. This author states further, p. 118, that it is doubtful whether the ascosporic stage plays any important part in perpetuating the fungus. The writer had made diligent search for it in many of the vineyards of the State, and had attempted to develop it in culture, but up to the present time has not succeeded in finding it.

The perithecia of the fungus, as described by Shear, are buried in a stroma of fungous and host tissue occurring beneath the cortex. The cortex is lifted up but the stroma does not become exposed as in the case of the pycnidia. The perithecium is globose, thin-walled, and provided with a short, smooth beak which extends through and slightly beyond the cortex (Fig. 8). Within the perithecium are numerous cylindrical asci measuring 60 to 72 by 7 to 8 μ, each containing eight ascospores. The ascospores are subelliptical, colorless, one-celled and measure 11 to 15 by 4 to 6 μ. Between the asci are slender, septate, sterile threads known as paraphyses.

FIG. 8.— PERITHECIAL STROMATA OF *C. viticola*. (After Shear.)

The fact that this stage of the fungus has never been found in the State although diligent search has been made for it, both before and since the appearance of Dr. Shear's paper, makes it reasonably certain that the perithecial stage of the fungus plays no important rôle in the dissemination or perpetuation of the fungus with us.

Pycnidia.— This stage of the fungus is very abundant. It commonly occurs in the bark of the previous season or of two seasons previous. Fig. 9 (Plate VIII). The young pycnidium forms immediately underneath the layer of cork of the last annual ring of bark. Fig. 12 (Plate IX). As it increases in size it lifts up this cork layer and the larger portion of the pycnidium is to be found on the outside.

On the berry the stroma develops in the hypodermal parenchyma

immediately beneath the epidermis and distorted parenchyma cells are frequently included in it. With the enlargement of the pycnidium the underlying cortical tissue is compressed somewhat, giving increased area within the collapsing berry and the epidermis and cuticle are lifted so that the pycnidium breaks through and develops on the outside to approximately the same extent that it does inside. Fig. 11 (Plate IX). The pycnidia on the woody parts are to be found in greatest abundance in early spring. After the June rains only the base of the pycnidium remains and later the cavity in the tissue occupied by the pycnidium is the only visible evidence of this stage.

Canes which are severely infected the previous season often develop great quantities of the pycnidia, while occasionally pycnidia are developed on the current season's growth. In a vineyard where lightning had run the length of the wires of the trellis a great many shoots were damaged and many of the internodes rendered pithless.[3] On such shoots pycnidia of the fungus were found abundantly. Some of these shoots showed the typical black lesions of the disease as did shoots on neighboring vines in other rows, but the pycnidia were developed abundantly and without regard to the occurrence of lesions. The writer would be inclined to interpret the condition illustrated by Selby and Van Hook (1907) in the same way.

On July 12, 1909, a green shoot was found bearing mature pycnidia. This is the only instance of such a condition ever noted, except, of course, that the pycnidia develop abundantly on the green or ripening fruit.

The pycnidium (Fig. 10 — Plate IX), which is dull black externally, is occasionally a simple flask-shaped body. Usually, however, the inner walls are convoluted and sometimes so much so that there is an appearance of several pycnidia united in a common stroma of fungous tissue (Fig. 12 — Plate IX). The walls of these chambers are densely lined with a basidial layer of conidiophores from the ends of which the spores are abstricted. Interspersed among the conidiophores there are usually other conidiophore-like bodies bearing

[3] Sometime prior to 1905, Professor Whetzel received specimens of a diseased vine from a vineyardist near Hammondsport, N. Y. An organism was isolated and carried in culture for a long time under the label "pithless cane fungus." Unfortunately the culture finally died out and was discarded. There seems to be no specimen preserved, but from having made numerous test tube transfers of the organism, the writer is of the opinion that this was the dead-arm fungus.

at their tips long, slender, curved bodies which the writer in his former bulletin called paraphyses. This name was used simply because other writers have referred to similar bodies in other species of Fusicoccum as paraphyses. Shear (1911) has chosen to call them scolecospores. In the writer's opinion this is a much better name. The name paraphysis might well be confined to designating the structures occurring between the asci in ascomycetes.

No one seems thus far to have been able to germinate the scolecospores. Whether they should be regarded as a spore form which has ceased to function or whether they are really sterile bodies which serve to separate the somewhat sticky spores may be considered an open question. The scolecospores are always curved towards the ostiolum of the pycnidium and may be found frequently in the pycnidium after all the spores have been discharged. For the most part, however, they seem to ooze from the pycnidium with the pycnospores.

Exudation of spores.— The pycnidium is mature shortly after the bursting of the buds in the spring. If an infected cane or arm is placed in water the pycnidia above the water line will, in the course of a few hours, become prominent on account of the presence of a reddish-yellow ball or long curl of exuded pycnospores. The pycnospores are usually accompanied by a quantity of the scolecospores. If moisture is supplied from the outside as in the case of falling rain the exudation occurs in a similar manner. The actual number of spores that is formed is enormous. A single curl often consists of several thousand spores. When moisture is supplied to the mature pycnidium from below, the spores exude and cling at the mouth of the pycnidium, often drying down there and becoming nearly coriaceous. A drop of water lodging on the spore-stream, however, quickly sets the individual spores free and they float rapidly away.

No further explanation of the discharge of the spores from the pycnidium than that offered in the former bulletin can be given. It would seem that the spores must be surrounded by a mucilaginous substance which expands greatly in the presence of water. Presumably the same substance is active in effecting the rapid movement of individual spores when placed in a drop of water. At any rate they move about much as though a drop of alcohol had been drawn

into the drop of water, setting up unequal tension and producing darting, whirling motions.

As the spores are exuded from the pycnidia, spattering drops of rain carry them to young shoots a few feet away while many are washed to the shoots immediately under the infected arm. As is usually the case, however, the majority of the spores are washed to the ground where they perish. The spores find conditions favorable for germination in the clinging drops of water which persist on the shoots for many hours during periods of continued fog and rain. Ordinarily the temperature is quite low at such times. In 1912, for example, the chief and almost the only infection of the season occurred throughout the Chautauqua and Central Lakes regions on May 28th and 29th. These were days of continuous mist and fog. Foliage of trees and vines was completely enveloped in moisture but the fog was not heavy enough to cause dripping from the foliage except in case of slight puffs of air. It seems quite certain that infection in 1909 occurred on May 28th also. Careful records were being kept in a vineyard at Romulus for the black-rot infection periods. The first black-rot infection of the year occurred on that date and it is believed that most if not all of the infection by Cryptosporella occurred at the same time.

Spore germination.— No attempts have been made to germinate spores of the fungus at the same time that infections were probably taking place under natural conditions. Under more favorable conditions as to temperature it has been possible to germinate the spores, so that they had long germ tubes at the end of 18 to 24 hours. Many attempts have been made to germinate spores on detached leaves and stems in order to study the entrance of the germ tube. Unfortunately no cases have ever been observed.

Meteorological relations.— From what has been said above in regard to the exudation of pycnospores it may be inferred that weather conditions play an important rôle in the dissemination and occurrence of this fungus. It will be recalled that moisture is required for the exudation of spores. Clinging drops of water are necessary for the germination of spores and these drops must persist for a number of hours. Since the major infections of the season are known to occur during the early growth of the vine, that is, during the development of the first three or four internodes, the conditions favorable for infection may be said to be a relatively low tempera-

ture accompanied by rain, preferably gentle rain, followed by mist and fog. The rain is essential for the discharge and distribution of the spores, but gentle rain and fog are more favorable for the lodgment of the spore in a single place where it may germinate. No difficulty has ever been experienced in bringing about germination at various temperatures so that the low temperature usually attendant on infection periods doubtless should be regarded as an incidental meteorological condition. The low temperature actually retards the germination of the spores and thus aids in reducing the amount of infection.

Period of incubation.— After the germ tube of the spore effects an entrance into the interior a considerable period of time elapses before a lesion is apparent. Gregory (1913) records a period of incubation of about 30 days. Inoculations on the green shoots of vines in the greenhouse by Gregory, using a strain isolated from fruit, gave lesions in about a month. Also inoculations of shoots in the greenhouse with spores from a culture kept pure for four years gave lesions in approximately the same length of time. In 1908 when infection was supposed to have occurred on May 28th, lesions were found abundantly on June 26th. In 1909 infection probably occurred on May 28th, while lesions were found abundantly on July 1st. Possibly a search for these a few days earlier would have revealed their presence. In 1912, when infection occurred on May 28th[4] and 29th, unusually abundant infections were apparent on July 3d. How much earlier than this date they appeared is not known. Finally, the writer, as recorded later, inoculated young shoots on May 21, 1913, and found the first well-developed lesions June 23d. It would seem then that approximately 30 days are required before the lesions caused by the fungus are evident.

For the most part only a single period of infection occurs in any given year. This is evident from the fact that the lesions appear almost entirely at the base of the shoots, usually between the first three internodes. It is possible that the tissue of the host is not susceptible after a certain period, as in the case of the black-rot fungus. The more plausible explanation, however, would be that the spores were all matured and discharged at about the same time. For the most part it is impossible to find pycnidia with spores after

[4] It is only a coincidence that prolonged periods of rain and fog should have occurred three different years on this date.

the end of June, although some spores must persist to cause infection on the nearly mature fruits.

In his former bulletin the writer did not regard the infection by spores as seriously as he now does. The suggestion was made there (p. 338) that carrying of diseased material on shears and saw to healthy vines was probably the greatest means of spreading the disease. After more extended observation and experiment it becomes obvious that the importance of shoot infection by means of spores was greatly underestimated. The first intimation of the importance of this method of infection came when a cane taken early in the spring and bearing evident lesions on the peeling bark was placed in a moist chamber for a few days. Great quantities of pycnidia matured and exuded their spores. Further observations along this line confirmed the growing suspicion that the fungus might enter the more permanent wood of the spur, arm or trunk by way of the infected cane tied up for bearing wood. It is not to be expected that every cane which was infected the previous summer will develop the disease but the number that do so is surprisingly large. If only a few spots are produced on the shoot, the resulting cane may bear a crop the succeeding year and be removed before the fungus has had an opportunity to grow down into the more permanent parts. On the other hand, if the infections are numerous and the bark of the shoot broken up into a succession of roughened ridges on the upper side, there is a possibility, in case the cane is saved for bearing wood, that marked symptoms of the disease will develop during the bearing period of the cane, and at all events the probability of the fungus gaining entrance into the arm is greatly increased.

Mycelium.— The mycelium developed from the germinating spores does not differ strikingly from the vegetative portions of many other fungi. The individual strands are hyaline, thin-walled, varying from 1.2 to 2.6 μ in diameter. The growth of the mycelium through the tissue is slow. The truth of this is nowhere better brought out than in inoculation experiments reported in detail elsewhere in this bulletin. Figure 13 (Plate X) shows what progress was made in a period of 12 months by mycelium and spores of a strain of the fungus (3229) isolated July 2, 1909, from material collected at Fredonia, N. Y., and inoculated into a healthy trunk on July 12, 1909.

It should be borne in mind, however, that this diseased area extends a third of the way around the stem as well as the distance up and down indicated in the photograph. It should also be borne in mind that the fungus was inserted at only one point, whereas in nature it frequently happens that a mycelial development occurs at a dozen or at a hundred different points.

TRANSMISSION OF THE DISEASE THROUGH DISEASED NURSERY STOCK.

The writer suggested in his former bulletin the possibility of transmitting the disease to the vineyards through diseased nursery stock and cited instances where this might have been the case. The complaint frequently mentioned by growers is that vines apparently grow well for the first few years but frequently in their fourth year die for no apparent reason. It would seem quite plausible to expect the disease to be transmitted in such a manner and the occurrence of disease the fourth year in the vineyard would accord very well with the slow development of the fungus. The following experiment was designed to throw some light upon the above consideration.

In July, 1908, numerous infected shoots were marked in a vineyard at Romulus, N. Y. In October these were cut into proper lengths and layered in sand in the greenhouse. On May 4, 1909, the cuttings were taken to Fredonia and planted in a nursery row. Many of the cuttings failed to callus, some were entirely dead, and others half dead. Examination revealed the presence of the pycnidia of Cryptosporella, some of which were practically mature. No record of the number of cuttings that died was made. One hundred sixty-one (161) cuttings were placed in the soil on May 5, 1909. The season was not particularly favorable for the growth of the cuttings. Many developed pycnidia of Cryptosporella during the summer and made a slight growth or failed to put forth any buds at all. On August 17, 1909, there were only 36 plants living and some of these came out so late that there was little hope of their living through the winter. Examination June 26, 1910, showed that thirteen (13) died during the winter, leaving only 23 "roots". A number of the dead vines were examined and the fungus found abundantly on them. Isolation cultures were made from some and the dead-arm fungus obtained without any difficulty. An examination August 29, 1910, showed that

two vines had been broken by accident. Of the twenty-one remaining seven showed spots of the fungus on the shoots, the remaining fourteen appearing healthy. September 29, 1910, the vines were removed to Ithaca and heeled in for the winter. Some vines were lost in some manner so that only fifteen vines were set in the disease garden in the spring of 1911. On November 4, 1911, there were eleven vines in good condition, one very weakly appearing one, and three dead. It is not certain whether the three died from disease or from the excessively cold winter and the late planting, or a combination of these factors. The latter seems most probable. October 12, 1912, the following notes were made on the general condition. Two were struck by the plow and died.

Vine 3, good growth, two shoots infected, one ripe rot berry.
Vine 4, excellent growth, most of the shoots infected.
Vine 5, excellent growth, one arm with tuberculous growth, one arm practically dead.
Vine 6, good growth, most of the shoots apparently infected.
Vine 7, fair growth, severely infected shoots.
Vine 8, fair growth, apparently a few infections on shoots.
Vine 9, good growth, apparently healthy.

A similar lot of material was started in 1909 with the same end in view. The record of growth to date is very similar to that already given and may be chronicled here in the brief notes made from time to time.

1909, July 15, shoots marked in vineyard at Romulus, N. Y.
November 29, cuttings made and buried in a box in the garden.
1910, March 31, 230 cuttings were taken to Fredonia and placed in soil.
June 23, most of the cuttings appear to be alive at this date.
July 17, many of the cuttings dead. Cryptosporella present in abundance and pycnidia oozing spores after 24 hours in a moist chamber. The photograph in Plate IV, C, was obtained from one of these cuttings.
August 29, only 17 plants with leaves; some others appear alive but if leaves were put forth now the vine would probably winterkill.
September 29, vines moved to Ithaca.
1911, May 14, ten vines set in disease garden.
November 14, eight vines now alive in the garden, the other two vines probably died from severe winter and late planting.
1912, October 12, vines in the following condition:
Vine 1, excellent growth, apparently healthy.
Vine 2, fair growth, apparently healthy.
Vine 3, excellent growth, 2 dead arms, some shoots apparently affected
Vine 4, good growth, apparently healthy.
Vine 5, good growth, apparently healthy.
Vine 6, fair growth, apparently healthy.
Vine 7, good growth, 2 dead arms, 1 shoot infected.
Vine 8, good growth, apparently healthy.

The first lot of cuttings did not have the most favorable conditions for growth, but the second lot was favored in every way. It seems quite evident therefore that the high percentage of mortality must be credited to the dead-arm fungus. If this is the case, the disease in this phase of its development is one of interest primarily to the nurserymen, and the transmission of the disease through nursery stock would appear to be of little consequence. Unfortunately it is now evident that the experiment was not perfectly planned. The cuttings used in both of the experiments were quite badly or even severely infected when they were taken. While the writer is not thoroughly familiar with the practice of nurserymen with respect to making cuttings it would seem that the very short internodes near the base of the cane would not serve particularly well for this purpose and it seems rather doubtful whether badly diseased internodes would be saved for cuttings. In any case such a practice in the future is very unwise for the nurseryman. The experiment would have been of much greater value if canes bearing only one or two spots or possibly half a dozen had been used. Such conditions would have given the cutting every chance to become established and at the same time would prolong the time until the fungus could spread to various parts of the tissue. It is quite probable that such cuttings would make vines that could be sold and which might grow for several years without showing marked evidence of disease.

CONTROL.

ERADICATION.

The method of control described in the former bulletin is still the best and most obvious way of holding this disease in subjection. Since the publication of that bulletin a great many growers in Chautauqua county have given more attention to the prompt removal of diseased wood and the renewal of the vines with new growth from below the surface of the ground. However, certain features are still open for great improvement. Many persons apparently are not yet fully conversant with the fact that the vines which show a dwarfed, crimped and yellow-colored leaf during the early part of the season are affected with the dead-arm disease. This characteristic symptom is of the greatest value in locating vines in the first

stage of the disease. Since these characters show best during June, a time when cultivation is frequent, there is really no excuse for not locating practically every diseased vine in the course of two or three seasons. Such vines should be marked for removal or for special consideration at trimming time. The most convenient method of marking such vines is to carry about a piece of old cotton or linen cloth from which short strips may be torn as occasion demands. These strips should be tied to the affected vines or to the wire. At trimming time they are very conspicuous and are a reminder that the vine needs special attention. Oftentimes the removal of a single arm eradicates the disease. In other cases it will be found that the whole trunk is affected. In case the characteristic discoloration and dry rot is apparent in the main trunk of the vine, the vine should be sawed off at a point some distance below the last indications of rot. In many cases it will be advisable to remove the vine near the ground. This will insure the renewals coming from below the surface. The importance of thus marking and removing early all vines showing symptoms of disease cannot be emphasized too greatly. Some growers make a practice of obtaining some fruit from the diseased vine while a renewal is being trained up. Some years this is a safe thing to do but in other years is a very costly procedure. The great danger lies in the fact that the fungus is almost sure to fruit somewhere on the old dead parts and infect the tender shoot which is saved for the renewal. If all source of infection is removed the renewals are sure to grow healthy and develop rapidly into strong vines.

Every renewal should be inspected carefully sometime during the late summer to see that it has not been infected from some neighboring vine or from chance spores carried in from another source. If a renewal shows any indications of being infected it should be rejected. As a general rule it is well to leave two or three suckers at the base of the stump in order to have a selection from which to tie up.

At the regular trimming time precaution should be made not to leave for bearing wood any canes that show lesions of the disease. At that time the lesions are reddish in color, are slightly elevated, and for the most part are conspicuous. It would be advisable to put up fewer canes than desired rather than to leave affected canes.

The writer feels very strongly that sufficient attention is not given

the vines at trimming time. In many respects the trimming of the vine is the most important operation of the whole year and this is unquestionably true when this disease is present. It is a most unfortunate practice to leave the pruning of the vines to a so-called professional "trimmer", unless the character of his work is well known. It is even more unfortunate to hire the work done by the acre. The writer has seen the work of some professionals which could not be called good pruning and it was very evident that they were either ignorant of or indifferent to methods of eliminating disease.

An eradication experiment.— When the writer began a serious study of this disease in the spring of 1908, and before it was known that the lesions on shoots were in any way connected with the disease, a number of affected vines, approximately 20 years old, were sawed off near the ground and used for cultural and other studies. In most cases a sucker was tied up in place of the vine removed.

As such a method of renewal was being practiced by at least one grower in Chautauqua county a record was made of twenty-three vines thus removed.

Although it was realized before the summer was over that a record of the development of these renewals would mean little in regard to the practicability of such a method of control, owing to the discovery of the fact that the fungus produced infections on the shoots and that some of the shoots tied up were unquestionably infected, it was thought, nevertheless, that a sufficient number would be found free from infection and enough others unquestionably affected to make it worth while to keep a record of development. Accordingly observations and records were made June 8, 1909, August 2, 1910, July 28, 1911, and July 26, 1912, which appear in Table I. Those vines recorded as infected when tied up (condition in 1908) were not examined until June 8, 1909, but at that time unmistakable lesions were evident on the canes. Those vines recorded as questionable did not show lesions and persumably a number of them were healthy. Vines 16 and 18, however, were undoubtedly infected when they were tied up.

Table I (pp. 270–1) shows that renewed vines may be brought into profitable bearing quickly by the renewal system and also shows most strikingly the slowness with which the fungus works. Some of the

suckers tied up were heavily infected and yet few of them died in less than three years.

Spraying.— In regions where black rot is serious the first application of spray for that disease, when the shoots are eight or ten inches long, should prove very effective in preventing new infections on the shoots. Here, as in the case of black rot, it is absolutely essential that the spray be applied before periods of prolonged rain. The method employed in determining these periods in actual vineyard practice are detailed in a number of places, all of which are available to the vineyardist who must spray for black rot.

The black rot disease has rarely caused damage in the Chautauqua belt and the writer knows of only one person who does any spraying with the view of warding off this disease. Therefore, if any early spraying is done it must be with the idea of controlling the infection of the dead-arm fungus on the shoots. Since the majority of growers cannot persuade themselves of the necessity of making the two sprayings required to control the root worm, even though it has been known since the work of Professor Slingerland (1906) that spraying is effective, and in view of the fact that a relatively small number of growers own spray machines it seems nearly useless to recommend this method of control. Nevertheless there are a number of vineyards in which the early application of bordeaux mixture would prove well worth while.

The nurseryman who has a vineyard in connection with his establishment from which to obtain cuttings should make the early applications by all means. If he obtains cuttings from growers he should insist that the vineyard be sprayed, unless a careful inspection reveals the fact that the canes are free from the disease. Such vineyards are relatively scarce. Even though the cost of the cuttings were increased either on account of spraying or inspection, the initial cost would be recompensed by reduced mortality.

In certain years weather conditions are such that practically no infection occurs. The year 1910 was of this character. Such conditions cannot be forecast, however, so that the spraying cannot be omitted.

INFECTION EXPERIMENTS.

In order to test the pathogenicity of this organism and to determine in what manner the fungus might gain entrance to the tissues a number of inoculation experiments have been performed.

TABLE 1.—RECORD OF OBSERVATIONS ON DISEASED VINES RENEWED BY SUCKERS FROM THE BASE.

Some of the suckers were infected, others apparently free from disease.

Vine No.	Condition of old vine.	Where cut off.	Renewal.	Condition 1908.	Condition 1909.	Condition 1910.	Condition 1911	Condition 1912.
1....	Dead..........	Near ground..	In second year..	Infected......	Apparently healthy.	Apparently healthy.	Small but apparently healthy.	Bearing crop of small clusters. One arm badly diseased.
2....	Dead..........	Near ground..	Sucker.........	Infected......	Apparently healthy.	Apparently healthy.	Fair size; evidently diseased; narrow area at base dead.	Dead. Pycnidia present. Renewal suckers infected.
3....	Dead..........	Near ground..	Sucker from beneath ground.	Infected......	Apparently healthy.	Vine fair size, apparently healthy.	Apparently healthy; stem half dead.	Apparently healthy except longitudinal excrescences.
4....	Dead..........	Near ground..	Sucker.........	?	Broken off; sprout diseased.	Apparently healthy.	Healthy, small..	Healthy, small.
5....	Dead..........	Near ground..	Sucker.........	Infected......	Apparently healthy.	Apparently healthy.	?	Healthy; good crop.
6....	Dead..........	Near ground..	Sucker from beneath ground.	?	Doubtful.......	Apparently healthy.	Strong, healthy vine.	Healthy; good crop.
7....	One dead arm, other chlorotic.	Near ground..	Sucker.........	?	Probably infected.	Apparently healthy.	Strong vine, one shoot infected.	Strong vine.
8....	Dead..........	Near ground..	In second year...	Probably free..	Healthy........	Healthy........	Strong vine.....	Strong vine.
9....	One green shoot, leaves chlorotic.	Near ground..	Sucker.........	?	Healthy........	Healthy........	Large, vigorous vine.	Gone or else very strong vine.
10....	Chlorotic shoots no fruit.	Near ground..	Sucker from below ground.	?	Broken off......	New sucker from above ground.	Healthy.......	Strong vine.

TABLE 1.—RECORD OF OBSERVATIONS ON DISEASED VINES RENEWED BY SUCKERS FROM THE BASE — (*Continued*).

Vine No.	Condition of old vine.	Where cut off.	Renewal.	Condition 1908.	Condition 1909.	Condition 1910.	Condition 1911.	Condition 1912.
11....	Dead..........	Near ground..	Sucker one foot above ground.	?	Apparently healthy.	Apparently healthy.	Small and weak..	Apparently healthy.
12....	Chlorotic shoots; no fruit.	Near ground..	Two suckers....	?	Broken off......	Healthy shoots..	Fair, vine healthy.	Fair, vine healthy.
13....	Chlorotic shoots; no fruit.	Near ground..	Sucker.........	?	Apparently healthy.	Apparently healthy.	Dead.	
14....	Dead..........	Near ground..	Healthy suckers in 1910.	....	....	Healthy........	Large vine......	Healthy; good crop.
15....	Nearly dead....	Near ground..	Sucker.........	?	?	?	?	Healthy and vigorous.
16....	Nearly dead....	Near ground..	Sucker.........	?	Diseased.......	Dead.		
17....	Dead..........	Near ground..	Sucker from below ground.	Infected......	Apparently healthy.	Apparently healthy; shoots infected.	Dead. Suckers all infected.	
18....	Dead..........	Near ground..	Sucker from below ground.	?	Apparently healthy.	Apparently healthy; shoots infected.	Dead.	
19....	One dead arm...	Base of arm...	....	....	....	....	Upper half dead.	Nearly dead.
20....	One dead arm...	Base of arm...	....	....	All arms diseased	....	Small and weak..	Dead; suckers infected and chlorotic.
21....	Chlorotic.......	Near ground..	Sucker.........	?	Healthy........	Healthy........	Healthy; small..	Healthy; vigorous.
22....	Chlorotic.......	Near ground..	Sucker.........	Infected......	Apparently healthy.	Apparently healthy.	Strong vine.....	Healthy and vigorous.
23....	Slightly diseased.	Near ground..	Sucker.........	?	Healthy........	Healthy........	Strong vine.....	Healthy and vigorous.

SPRAYING SPORES ON GREEN PARTS

The pathogenicity of the fungus has been established by spraying spores on tender shoots (Gregory, 1913). The writer was not successful in his earlier attempts to obtain infections in this way. The failures are readily attributed, however, to the fact that inoculations were not made at the most opportune times. Circumstances did not permit trials in the early stages of new growth. Later in the season great difficulty was experienced, both in 1909 and in 1910, in maintaining spore-laden drops of water on the vines for any appreciable length of time. The wind blowing off Lake Erie in the day and towards the lake at night, dried up the moisture before the spores had an opportunity to germinate. The following paragraph copied verbatim from notes written July 10, 1909, gives an idea of the method of making inoculations and the results obtained:

"An enormous quantity of spores of the dead-arm fungus (3216)[5] from pure culture were placed in boiled rainwater in an atomizer and sprayed on all the vines (38) of row two in the experimental block. There had been a heavy rain and even as the spores were being sprayed on (between 8 and 9 p. m.) the rain was falling. So far as I can find no rain fell after ten o'clock. The wind blew while the spores were being applied and presumably all night. The vines are perfectly dry at seven a. m. this morning."

Similar trials were made in 1909 with various strains of the organism, isolated from different places, on June 22d and 23d, and on July 10th, three different trials were made. In 1910 two trials were made on July 12th, one each on August 18th and 31st, and one on September 4th. The vines sprayed on August 18th were small and were covered with a bell glass.

In one case a sprayed row seemed to show an unusual amount of scattering infections, which is not usual, as well as a greater number of infections than neighboring vines. The number of spots was not sufficient, however, to justify the assumption that the spores sprayed on the vines caused the infections, particularly since the presumed period of incubation was not observed nor recorded and cannot therefore be checked against more definite records.

Inoculations with pure cultures of the fungus (No. 3221, original culture made April 16, 1908) were made May 21, 1913, by suspend-

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[5] The figures refer to specimen numbers in the collection of the Department of Plant Pathology, Cornell University.

ing spores in sterile water and spraying them on the young shoots of several small vines. Contemporaneous germination tests of spores in drops of water on glass slides gave 80 to 90 per ct. germination at the end of 20 hours. The plants were entirely covered with bell glasses for 24 hours. Infection was also favored by humid external conditions. Other plants were sprayed with sterile water, but otherwise subjected to the same treatment. They remained healthy. In 30 days (June 20th) lesions became evident on the inoculated plants and when they increased in size some of the stems were completely involved.

July 22d some of the infected shoots were sterilized externally by immersing in mercuric chloride solution 1–1000. Thin shavings of epidermis were removed with a sterile scalpel and bits of the underlying diseased tissue transferred to sterile grape stems in tubes and to potato agar slants. August 5, 1913, the tubes were examined. The Fusicoccum stage of the fungus had developed and was producing spores in six of the ten grape-stem tubes. Two tubes were sterile and one was contaminated. A similar growth of mycelium appeared in five of the eight agar slants, and had the appearance of the dead-arm fungus when grown on potato agar, two tubes remained sterile and one was contaminated.

Two things are of interest in connection with this experiment. (1) The pure culture used for inoculation purposes had been kept alive through successive generations in test tubes for five years. At the end of that time it still retained its virulence as indicated by the abundant infection obtained and by the appearance of lesions after the characteristic period of incubation as noted under natural conditions. (2) The susceptible parts of the vine are limited to the tender, more succulent growth. The infected area on the shoots inoculated was confined to about two internodes, but stem, leaf petiole, leaf veins, tendrils when present, and apparently leaves within this range bore lesions. Older parts were not affected.

In the light of these experiments the failures in the earlier attempts are readily understood. In addition to unfavorable atmospheric conditions it appears that the host had passed the period of susceptibility. The trial of July 12, 1910, was made under fairly favorable conditions in that a heavy rain at 12 m. was followed by calm, cloudy weather which permitted drops to cling to the canes. A quantity

of such drops were collected in a clean atomizer and inoculated with the spores of the Fusicoccum stage of the fungus (2971) from culture. These spores were sprayed on a large number of shoots of Concord vines. Clinging drops of water were then examined and an abundance of spores found. Contemporaneous germination tests on glass slides showed the spores to be viable. No lesions developed on any of the shoots, although the tips were relatively tender.

INOCULATION WITH THE SAW.

First series.— In order to determine the effect on the vines as well as to serve as a check on the experiments about to be described, the trunks of six Worden grapes, eighteen years old, were cut half off with a saw, the cut being made near the ground. Twenty-eight other vines in the same row were treated in a similar manner except that the cuts were not all so deep and that in each case the saw was drawn a few times through a diseased stem and then through the cut previously made. In some cases the saw cuts were made near the arms or in the arms. The object of the experiment was to determine if possible what number of infections occur in this manner. All cuts and inoculations were made July 7, 1909. The infected wood used as a source of inoculation was taken from a vineyard at Prospect, N. Y., the previous day, and by examination with the microscope was known to be infected with the dead-arm fungus.

An examination was made on July 1, 1910, and notes taken on each vine. The vines used as check showed no ill effects of the treatment. The wood was found somewhat discolored for a short distance each way from the cut, in the vine examined, but otherwise seemed to be perfectly sound.

The remaining twenty-eight vines, without exception, showed an exudation of gum about the cut. There was no apparent effect on the vines but three or four were examined and it was found that a dead area extended in each direction a distance of one or two inches.

A second examination was made June 27, 1911. No healing of the wounds had occurred on the check vines. They showed no apparent effect of the treatment and none of them showed gum flow. Many of the inoculated vines still showed gum flow. In a number of cases a sunken pit an inch or more in diameter appeared about the cut. In one vine examined, the wood about the cut was found to be blackened and dead a distance of three inches each way

from the cut. Some cases were found where there was no apparent effect.

On the date of the third examination, July 3, 1912, three of the check vines showed evidence of disease, one apparently affected before the cuts were made. The lesions on the other two were well up in the vine and were removed in pruning.

Of the inoculated vines fifteen showed no apparent effect of the inoculation. Eleven of the remainder showed symptoms of dead-arm disease, some apparently due to the inoculations. One vine was dead and removed and another very sickly but probably not from inoculation.

July 10, 1913, five of the vines serving as checks were in good condition. Of the inoculated vines eleven were recorded as in good condition. Four others seemed in fair condition while the remainder were nearly dead or in very poor condition. The vines were cut off near the ground October 22, 1913, and shipped to Ithaca. October 29th, the inoculated vines were split open and many were found to be decayed. In some cases the discoloration extended over half way through the stem and six inches or more up and down the stem from the original point of inoculation. Attempts were made to remove bits of the discolored tissue under aseptic conditions and transfer them to sterilized grape stems. Of twenty-four such transfers made, nine developed pure cultures of the fungus, ten were contaminated so that it could not be determined whether Cryptosporella was present or not and five remained sterile. It appears from this set of inoculations that infection may occur from the pruning saw, that the fungus does not spread rapidly in the tissue and that discoloration of the woody tissue precedes the advance of the fungus. Examination of the checks failed to reveal the typical discoloration of the dead-arm disease. Some showed only a blackening of the wood as from weathering and others showed the lighter brown decay characteristic of the action of the fungus *Polystictus versicolor*. This only extended a short distance from the original cut.

Second series.— A series of inoculations was made June 22, 1909, in which spores and mycelium of the fungus from a pure culture (3221 isolated May 9, 1909, from exuding spores on 1-year cane) in its second generation were inserted in the cuts. The record for the thirty vines thus inoculated does not differ materially from that above except that most of the vines showed more striking symptoms

of the disease from year to year and more vines were dead or nearly so at the conclusion of the work in 1913. July 19, 1910, one of the vines in this row showed a marked sunken area near the saw cut which was covered with pycnidia. When placed in a moist chamber for a few days spores oozed from the pycnidia and a pure culture of Cryptosporella was readily obtained.

Third series.— On July 12, 1909, thirty-five vines (Worden) were inoculated as above, using spores and mycelium of the fungus from pure culture (3229, isolated from a diseased Concord stem July 1, 1909). On July 1, 1910, all the vines showed a copious flow of gum at the point of inoculation but there was no other apparent effect. June 27, 1911, the sunken areas at the point of inoculation were conspicuous. One vine examined showed dead wood nearly to the heart of the trunk. July 3, 1912, a number of the vines showed marked symptoms of the disease and one vine was entirely dead. July 10, 1913, eleven vines were dead or nearly so, five were in fair condition and eighteen were still apparently healthy. July 19, 1910, one vine was cut off and examined. The extent of the infection is shown in Fig. 13. Direct transfers of diseased tissue to sterile grape stems gave pure cultures of the fungus. A similar isolation was made October 29, 1913, from another of these vines with the same result.

INOCULATION BY INCISION ON SHOOTS.

July 1, 1909, each bearing shoot on thirty vines was inoculated by making a gash with a scalpel near the base and inserting mycelium and spores of the fungus (3216, isolated July 23, 1908, from vine 23 of Table I, and in its fourth generation in culture). July 1, 1910, gumming was observed about the majority of the incisions. One cane examined showed a blackening of the tissue for an inch or more from the point of inoculation. In the case of incisions made as a check a slight blackening may appear later, but does not extend any considerable distance from the original point of incision.

July 10, 1910, the fungus was readily recovered from two of the inoculated canes.

April 26, 1912, a number of the inoculated canes (now arms) were removed and pure cultures of the fungus obtained by direct transfer of diseased tissue. Later in the season, July 3, practically every vine showed marked symptoms of the disease and three of the arms trimmed and tied up were found to be dead. July 10, 1913, thirty-

one dead canes were counted on the vines of this row. Although the vines were partially renewed by tying up canes back of the point of inoculation the row was conspicuous on account of dead canes from the infected arms.

The same organism was inoculated into the canes of twenty-three other Worden vines on July 9, 1909. The photograph shown in Fig. 14, is one of these inoculated canes after fourteen months. Two dead arms were found in 1912, but in general the symptoms were not nearly so marked as in the set of inoculations on shoots.

A culture from a different source (3261) was used for inoculating a number of bearing shoots July 8, 1910. There was no noticeable effect in 1911, but in 1912 a number of arms showed marked symptoms and on one pycnospores were oozing in abundance. In July, 1913, there were a number of dead stubs and canes on the five vines inoculated.

INOCULATION OF ROOTS.

July 18, 1910, the soil was dug away from one side of seven Worden vines and several roots, both large and small, were inoculated through a scalpel wound near the root crown with mycelium and spores of the fungus (3261).

Observations from year to year failed to show any marked effect. In the autumn of 1913, the vines were pulled up and shipped to Ithaca without label. A careful examination was made of all the roots, but the original point of inoculation could not be located with certainty except in one instance. All the roots were examined, but in no case was there any evidence of disease. This bears out frequent observations that the diseased area does not as a rule extend below the surface of the ground, and is a point of considerable importance in control.

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REPORT

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REPORT OF THE DEPARTMENT OF CHEMISTRY.

PREPARATION, COMPOSITION AND PROPERTIES OF CASEINATES OF MAGNESIUM.*

L. L. VAN SLYKE AND O. B. WINTER.

SUMMARY.

1. *Preparation of solution of casein in magnesium hydroxide.*— In preparing magnesium caseinates, the solution of casein in magnesium hydroxide is effected by suspending pure casein in water with an excess of finely-divided magnesium oxide, allowing the mixture to stand several days with occasional agitation.

2. *Preparation and composition of basic magnesium caseinate.*— The magnesium hydroxide solution of casein is made neutral to phenolphthalein with HCl and the solution dialyzed and evaporated to dryness. The preparation contains 1.06 per ct. Mg (1.76 MgO), the theoretical composition being 1.09 per ct. Mg (1.81 MgO); or 1 gram of casein combines with 8.7×10^{-4} gram equivalents of Mg (theoretical, 9.0×10^{-4}). The compound is easily soluble in water and in a 5 per ct. solution of NaCl.

3. *Preparation and composition of neutral magnesium caseinate.*— The magnesium hydroxide solution is made neutral to litmus with HCl and the solution dialyzed and the caseinate precipitated with alcohol. The preparation contains 0.71 per ct. Mg (1.18 MgO), the theoretical composition being 0.67 per ct. Mg (1.12 MgO); or 1 gram of casein combines with 5.8×10^{-4} gram equivalents of Mg (theoretical, 5.6×10^{-4}). The compound is easily soluble in water and in a 5 per ct. solution of NaCl.

4. *Preparation and composition of mono-magnesium caseinate.*— A solution of base-free casein in magnesium hydroxide is treated with HCl just to the first point of precipitation and then dialyzed. Alternate addition of acid and dialysis are repeated, until finally the dialyzed solution forms a permanent precipitate on the addition of any acid. To this solution is added one-third of the amount of acid required for complete precipitation of the casein, the solution filtered and dialyzed and divided into two portions. One portion is used for the preparation of mono-magnesium caseinate by incomplete precipitation with HCl. The preparation contains 0.13 per ct. Mg (0.22 MgO), which is the theoretical composition; or 1 gram of casein combines with 1.1×10^{-4} gram equivalents of Mg. This compound is insoluble in water but soluble in 5 per ct. solution of NaCl; at 65° C. it tends to form strings when drawn out.

* Reprint of Technical Bulletin No. 33, February.

5. *Preparation and composition of di-magnesium caseinate.*— To the second portion of the solution mentioned in the preceding paragraph acid-free alcohol is added and a precipitate obtained which contained 0.24 per ct. Mg (0.40 MgO), the theoretical composition of di-magnesium caseinate being 0.26 per ct. Mg (0.44 MgO); or 1 gram of casein combines with 2.1×10^{-4} gram equivalent of Mg (theoretical 2.25×10^{-4}). The compound is quite easily soluble in water and in a 5 per ct. solution of NaCl; at 65° C. it is slightly sticky.

6. These four magnesium caseinates correspond to the four calcium caseinates which have been previously prepared, representing octo-, penta-, di- and mono-caseinates of magnesium.

INTRODUCTION.

In Technical Bulletin No. 26 of this Station, Van Slyke and Bosworth report a study of compounds formed by casein with the elements of several alkaline and alkaline-earth bases. In the case of calcium, for illustration, it was found that at least four caseinates could be formed, (1) mono-calcium caseinate, (2) di-calcium caseinate, (3) neutral (or penta-valent) calcium caseinate, neutral to litmus, and (4) basic (or octo-valent) calcium caseinate, neutral to phenolphthalein. It seemed desirable to undertake a similar study to ascertain whether casein forms corresponding compounds with magnesium. The details of this work are given in this bulletin.

DETAILS OF LABORATORY WORK.

SOLUTION OF CASEIN IN MAGNESIUM HYDROXIDE.

In the preparation of caseinates of the alkaline-earth elements, the first step in the process is to obtain a solution of casein in the hydroxide. In the case of magnesium, its hydroxide is only slightly soluble in water and the solution is so dilute as to have very little effect in dissolving casein. It was found, however, that when casein is suspended in water with an excess of finely-divided magnesium oxide and allowed to stand several days with occasional agitation, enough casein is taken into solution to furnish material which can be used in the preparation of magnesium caseinates.

PREPARATION AND COMPOSITION OF BASIC MAGNESIUM CASEINATE.

Base-free casein (prepared in the manner described in Technical Bulletin No. 26, pp. 8–9) was dissolved in a solution of magnesium hydroxide containing an excess of magnesium oxide in suspension. The mixture was filtered and the filtrate was made neutral to phenolphthalein with hydrochloric acid; the end point was satisfactorily determined by adding the acid slowly until a faintly pinkish color remains for several minutes. The solution was then dialyzed to

remove the magnesium chloride formed in neutralization. The dialyzed solution was evaporated to dryness and finally dried at 120° C.

Analysis of the material showed it to contain 1.06 per ct. Mg (equal to 1.76 per ct. MgO). Calculated to correspond with basic calcium caseinate (containing 1.78 per ct. Ca or 2.50 per ct. CaO), this compound should contain 1.08 per ct. Mg (equal to 1.80 per ct. MgO). Expressed in another form, our results indicate that 1 gram of casein combines with 8.72×10^{-4} gram equivalents of magnesium (theoretical, 9×10^{-4}).

This compound is *basic magnesium caseinate*, the casein being octo-valent. The compound is easily soluble in water, its solution being neutral to phenolphthalein. It is also soluble in a 5 per ct. solution of NaCl.

PREPARATION AND COMPOSITION OF NEUTRAL MAGNESIUM CASEINATE.

Base-free casein was dissolved in a solution of magnesium hydroxide containing an excess of magnesium oxide in suspension. The mixture was filtered and the filtrate was made nearly neutral to litmus with $^{N}/_{10}$ HCl. The solution was dialyzed and then made neutral to litmus with $^{N}/_{10}$ HCl; the end-point was determined by adding the acid slowly, until both red and blue litmus paper could be left in the solution several minutes without change of color in either. The solution was then dialyzed again and the casein precipitated with acid-free alcohol; the mixture was then filtered, and the precipitate was washed thoroughly and was finally dried at 120° C.

Determination of the magnesium in this preparation gave 0.71 per ct. Mg (equal to 1.18 per ct. MgO). Calculated to correspond with neutral calcium caseinate (containing 1.10 per ct. Ca or 1.55 per ct. CaO), this compound should contain 0.67 per ct. Mg (equal to 1.12 per ct. MgO). Expressed in another form, our results indicate that 1 gram of casein combines with 5.84×10^{-4} gram equivalents of magnesium (theoretical 5.625×10^{-4}).

This compound is *neutral magnesium caseinate*, the casein being penta-valent. The compound is easily soluble in water and in a 5 per ct. solution of NaCl.

PREPARATION AND COMPOSITION OF DI-MAGNESIUM CASEINATE.

Solution of base-free casein in magnesium hydroxide containing an excess of magnesium oxide is effected in the manner already described. To the filtered solution, $^{N}/_{50}$ HCl is added until near the point of precipitation, as shown by a preliminary test (Technical Bulletin No. 26, pp. 15–17). The solution is then dialyzed. Alternate addition of acid and dialysis are repeated several times, until the addition of a small amount of acid to a test portion causes precipitation. The amount of acid necessary for complete pre-

cipitation is next determined, and about one-third of this amount is added to the solution. The mixture is then filtered to remove any precipitate that is formed and the filtrate is dialyzed to remove magnesium chloride as completely as possible. This solution, containing di-magnesium caseinate, is divided into two portions, one being used for the preparation of di-magnesium caseinate and the other for the preparation of mono-magnesium caseinate.

To one portion of the solution acid-free alcohol is added and a precipitate of di-magnesium caseinate obtained. This is thoroughly washed with acid-free alcohol and ether and dried at 120° C.

Determination of the magnesium in this preparation showed it to contain 0.24 per ct. Mg (equal to 0.40 per ct. MgO). Calculated to correspond with di-calcium caseinate (containing 0.44 per ct. Ca or 0.62 per ct. CaO), this caseinate should contain 0.26 per ct. Mg (equal to 0.44 per ct. MgO). Expressed in another form, our results indicate that 1 gram of casein combined with 2.14×10^{-4} gram equivalents of magnesium (theoretical, 2.25×10^{-4}).

Di-magnesium caseinate is slightly soluble in water; it is soluble in a 5 per ct. solution of NaCl at 65° C. and at this temperature is slightly sticky.

PREPARATION AND COMPOSITION OF MONO-MAGNESIUM CASEINATE.

In preparing mono-magnesium caseinate, the remaining portion of the solution of di-magnesium caseinate was treated with enough acid to precipitate three-fourths of the casein, the acid being added very slowly and with constant, vigorous agitation. The solution was filtered and the precipitated caseinate washed with water, alcohol and ether, after which it was dried for three days in vacuo over sulphuric acid.

Determination of magnesium gave 0.13 per ct. Mg (equal to 0.22 per ct. MgO). Calculated to correspond with mono-calcium caseinate (0.22 per ct. Ca or 0.31 per ct. CaO), this compound should contain 0.13 per ct. Mg (equal to 0.22 per ct. MgO). Expressed in another form, our results show that 1 gram of casein combines with 1.125×10^{-4} gram equivalents of magnesium, which agrees with the theoretical value.

Mono-magnesium caseinate is insoluble in water, but soluble in 5 per ct. NaCl solution; at 65° C. it shows a tendency to form strings when drawn out.

VALENCY OF CASEIN.

In Technical Bulletin No. 26, Van Slyke and Bosworth have shown from their work with calcium caseinates the combining power of casein in the different compounds prepared and studied by them. It is interesting to compare their results with those obtained with magnesium. In the following table we arrange the results ex-

pressed, for the purpose of more direct comparison, in the form of gram equivalents of element per gram of casein.

TABLE I.— VALENCY OF CASEIN AS SHOWN IN MAGNESIUM CASEINATES.

Different caseinates.	Valencies satisfied in each caseinate.	Gram equivalents of Ca x 10^{-4} per gram of casein.	Gram equivalents of Mg x 10^{-4} per gram of casein.	Gram equivalents of element x 10^{-4} per gram of casein corresponding exactly to valencies given in second column.
Mono-	1	1.11	1.125	1.125
Di-	2	2.21	2.14	2.250
Neutral	5	5.36	5.84	5.625
Basic	8	9.00	8.72	9.000

The agreement between the analytical results obtained (third and fourth columns) and those called for (fifth column) by the valencies of casein satisfied in each compound (second column) is marked; also the close agreement between the results obtained with calcium (third column) and those given by magnesium (fourth column) is satisfactory.

I. WHY SODIUM CITRATE PREVENTS CURDLING OF MILK BY RENNIN.* †

ALFRED W. BOSWORTH AND LUCIUS L. VAN SLYKE.

SUMMARY.

1. The addition of sodium citrate to milk in infant feeding is a frequent practice in cases in which the use of normal milk results in the formation of large lumps of tough indigestible curd in the stomach. The favorable results attending such use of sodium citrate have never been explained on the basis of actual investigation.

2. Work previously done by the authors suggested a chemical explanation of the observed facts and led them to test the matter by an experimental study of the action of sodium citrate on milk.

3. The addition of sodium citrate to normal milk increases the amount of soluble calcium in the milk, this increase resulting from a reaction between the calcium caseinate of the milk and sodium citrate, by which is formed sodium caseinate (or calcium-sodium caseinate) and calcium citrate. The reaction is reversible.

4. The curdling of milk by rennin is delayed by the presence of sodium citrate; when there is added 0.400 gm. of sodium citrate per 100 c.c. of milk (equal to 1.7 grains per ounce), no curdling takes place.

5. The curd produced by rennin in the presence of small amounts of sodium citrate (0.050 to 0.350 gm. per 100 c.c. or 0.20 to 1.5 grains per ounce) increases in softness of consistency as the amount of sodium citrate in the milk increases.

6. The results of our work indicate that at the point at which rennin fails to curdle milk we have in place of the calcium caseinate of normal milk a double salt, calcium-sodium caseinate; this double salt, when rennin is added, is changed to a calcium-sodium paracaseinate which, owing to the presence of the sodium, is not curdled.

7. The practice of adding sodium citrate to milk at the rate of 1 to 2 grains of citrate per ounce of milk appears to have a satisfactory chemical basis in the reaction between the sodium citrate and the calcium caseinate of the milk. The amount added is governed by the object in view, viz., whether it is desired to prevent curdling or only modify the character of the curd in respect to softness.

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† Reprint of part of Technical Bulletin No. 34, May; see p. 293.

INTRODUCTION.

The practice of adding sodium citrate to milk used as infant food has been common for many years. It has found application especially in the treatment of certain types of "feeding-cases" in which untreated milk, after entering the stomach, forms abnormally large chunks of tough curd, shown by Talbot [1] to consist of casein. These lumps of curd may pass practically unchanged through the entire intestinal canal, causing mechanical irritation, which often results in serious interference with the process of normal digestion. Empirical practice has shown that this abnormal curdling of milk may, to some extent, be modified or controlled by the addition of sodium citrate at the rate of 1 or 2 grains per ounce of milk. While various suggestions have been offered to explain the results observed, these have been based so little on demonstrated chemical facts as to partake largely of the nature of guesswork.

In our work [2] on the compounds of casein and paracasein we obtained certain results which appeared to suggest a simple and satisfactory explanation of the marked effect produced by the addition of sodium citrate to milk. Work has been done to test the application of the suggested explanation and the results are presented in this paper.

THEORETICAL CONSIDERATIONS.

In order that the details of our investigation may be more readily understood we will call attention to certain fundamental facts which have been brought out in our former work before we give the details of our present investigation. In the work to which reference is made in the paragraph preceding, the following points may be regarded as being established as far as the data now at hand enable us to reach any conclusions:

1. Casein is a protein showing the characteristic property of an acid in that it combines with metals or bases to form compounds known as caseinates.

2. The molecular weight of casein is 8888, and it can combine with eight equivalents of a monovalent metal or base. For example, the compound of casein containing the largest amount of a monovalent metal like sodium could be represented by the formula Na_8 casein (sodium caseinate); the corresponding calcium compound is Ca_4 casein (calcium caseinate).

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[1] Talbot, F. B. *Boston Med. and Surg. Jour.*, June 11, 1905, p. 205, and Jan. 7, 1909, p. 13.

[2] Van Slyke and Bosworth. *Jour. Biol. Chem.*, 14 : 206, (1913), and Technical Bull. No. 26, N. Y. Agricultural Experiment Station; also Bosworth: *Jour. Biol. Chem.*, 15 : 231, (1913), and Technical Bull. No. 31, N. Y. Agricultural Experiment Station.

3. Casein is present in milk in combination with calcium as calcium caseinate. It has not been definitely settled yet which particular compound is in milk, but it is probably either tetra-calcium or tri-calcium caseinate.

4. When the calcium caseinate of milk is acted on by rennin, it is changed into another compound called calcium *paracaseinate*. By this action one molecule of calcium caseinate is split into two molecules of calcium paracaseinate. Thus, assuming for the sake of our illustration, that the caseinate present in milk is the tetra-calcium compound, we can represent the change from calcium casinate to calcium paracaseinate in the following manner:

Ca_4 caseinate = Ca_2 paracaseinate + Ca_2 paracaseinate.

5. Paracasein, like casein, possesses acid properties, but has a molecular weight of 4444, only one-half that of casein. Paracasein, as an acid, has only one-half the combining power of casein; that is, its highest combining power is equal to four equivalents of a monovalent metal; for example, Na_4 paracasein (sodium paracaseinate), Ca_2 paracasein (calcium paracaseinate).

6. Calcium paracaseinate is *less soluble* than the corresponding calcium caseinate present in milk from which it is formed, and, therefore, it is precipitated as a solid, or, in ordinary language, the milk curdles.

7. If rennin is added to a solution of sodium caseinate, the caseinate is split into two molecules of sodium paracaseinate (for example, Na_8 caseinate = Na_4 paracaseinate + Na_4 paracaseinate), but no precipitation or curdling takes place. This is explained by the fact that sodium paracaseinate is very soluble. If, however, to this same solution of sodium paracaseinate we add a small amount of some soluble calcium salt (calcium chlorid, for example), curdling occurs at once, the curd being calcium paracaseinate. This precipitation or curdling is the result of a chemical reaction or double decomposition, which can be illustrated in the following manner:

Sodium paracaseinate (soluble) + calcium chlorid = calcium paracaseinate (insoluble) + sodium chlorid.

This reaction or equilibrium can be made to proceed in either direction at the will of the experimenter; for example, addition of excess of sodium chlorid changes insoluble calcium paracaseinate back into soluble sodium paracaseinate. These facts appeared to us to furnish an explanation of the action of sodium citrate when added to milk, in that there is formed calcium citrate and sodium caseinate, which latter compound is converted by rennin into sodium paracaseinate, a compound so soluble as not to curdle or form a precipitate. This hypothesis furnished the basis of our present investigation.

The facts stated above raise the query whether or not sodium citrate reacts with the calcium caseinate in milk to form sodium

caseinate and calcium citrate? If such a reaction takes place, we should be able to determine the amount of calcium thus transferred from the caseinate to the citrate. How this determination can be made we will indicate briefly.

When milk is filtered under pressure through unglazed porous porcelain (in the form of a Chamberland filter), the serum containing the filterable soluble portions passes through the filter, while the insoluble portion, consisting largely of caseinate and insoluble calcium phosphate, remains on the filter. If, therefore, milk treated with sodium citrate is filtered through a Chamberland filter, the amount of calcium in the filtered serum should increase with the amount of citrate added up to a certain point, provided that calcium citrate (or perhaps, a double salt of calcium-sodium citrate) is formed. It may be added here that calcium citrate is soluble to the extent of about 0.090 gm. per 100 c.c. of water at ordinary room temperatures, while the amount of calcium citrate formed by such a reaction in milk containing 3.2 gm. of casein per 100 c.c. has been found by us to be not over 0.066 gm. per 100 c.c.; it all, therefore, remains in solution passing through the filter into the serum.

If, then, we determine in milk the amount of soluble and insoluble calcium and then add to the milk sodium citrate, filtering and determining the calcium in the filtrate, there should, on the basis of our hypothesis, be an increased amount of calcium in the filtrate, showing how much calcium is transferred from the form of calcium caseinate to the form of calcium citrate.

EXPERIMENTAL WORK.

In carrying out our experimental work, we proceeded in the following manner: Fresh separator skim-milk was used, in which the amounts of casein, soluble and insoluble calcium, magnesium and phosphorus were determined. To prevent bacterial action, 3 c.c. of 40 per ct. formaldehyde solution was added to each liter of milk. The milk was then divided into nine equal parts and to each part was added, in varying amounts, crystallized sodium citrate (containing 27.7 per ct. of water of crystallization), as indicated in the table given below. The milk was then allowed to stand long enough for the reaction to reach equilibrium. Each portion was then filtered through a Chamberland filter and the amounts of calcium, magnesium and phosphorus were determined in the filtered serum. The results are given in Table I. Experiments were also made to test the effect of sodium citrate on the curdling action of rennin, the results of which are given in Table II.

Attention is called to the following points in connection with a study of the results contained in Table I.

1. *Changes in solubility of calcium.*— In the columns headed " calcium " we give the amounts of soluble and insoluble calcium in the

original untreated milk used in the experiments, and then, following, the amounts of soluble and insoluble calcium in the milk after treatment with amounts of sodium citrate varying from 0.130 to 1.040 gm. per 100 c.c. of milk (equivalent to 0.55 to 4.40 grains per ounce of milk). As previously stated, the soluble calcium is the portion appearing in the serum after filtering the milk under pressure through a Chamberland filter, while the insoluble calcium is that which fails to pass through the filter. An examination of the figures in the table shows that the amount of soluble calcium in 100 c.c. of the original milk is 0.045 gm. and this increases quite uniformly after each addition of increasing amounts of sodium citrate, the insoluble decreasing in essentially the same amounts. The only interpretation of these results that we can give is that some of the calcium of the caseinate or phosphate in the milk has been replaced by the sodium of the added citrate in the manner already discussed.

2. *Changes in solubility of phosphorus.*— The question suggests itself as to whether or not the increase of soluble calcium may come from action of sodium citrate on the insoluble calcium phosphate in the milk, forming sodium phosphate and caloium citrate. An examination of the figures in the columns under " Phosphorus " shows that there is no increase of soluble phosphorus until we have added more than 0.520 gm. of sodium citrate per liter of milk (equivalent to 2.20 grains per ounce), an amount sufficient to prevent curdling and even with larger additions the increase of soluble phosphorus is relatively small. The increase of soluble calcium comes, therefore, largely from the calcium that is combined with casein in the milk.

3. *Changes in solubility of magnesium.*— Owing to the small amount of magnesium in milk, the observed increase of solubility is slight but is in the direction shown by calcium, which would be expected.

In Table II we give the results obtained by treating 100 c.c. of milk with 2 c.c. of rennet solution (Shinn's liquid rennet) at 37° C. (98.8° F.). The rennet test was applied to untreated milk and also to samples of milk containing the varying amounts of crystallized sodium citrate given in the table.

Inspection of the results in this table makes it obvious that the presence of sodium citrate in milk, even in small amounts, delays very markedly the time of rennet curdling, while increase of citrate increases the time required for curdling, until we reach a point (0.400 gm. per 100 c.c. of milk or 1.7 grains per ounce), where no curdling takes place under the conditions of our experiments. It should be stated, in addition, that the character of the curdled milk varied in a characteristic way with the amount of sodium citrate added. Sample 1, untreated milk, gives a firm curd; the treated samples give curd of increasing softness with increase of sodium citrate.

The experimental results embodied in Tables I and II show that when sodium citrate is added to normal milk, (1) the amount of

TABLE I.— EFFECT OF SODIUM CITRATE IN INCREASING SOLUBLE CALCIUM, ETC., IN MILK.

No. of Experiment.	Grams of sodium citrate per 100 c.c. of milk.	Equal to grains of sodium citrate per ounce of milk.	Effect of adding 2 c.c. of rennet solution to 100 c.c. of milk at 37° C. (98.8° F.).	Grams per 100 c.c.					
				Calcium.		Phosphorus.		Magnesium.	
				Soluble.	Insoluble.	Soluble.	Insoluble.	Soluble.	Insoluble.
1	0.0	0.0	Curdled	.045	.101	.056	.035	.010	.004
2	0.130	0.55	Curdled	.052	.094	.055	.036	.010	.003
3	0.260	1.10	Curdled	.054	.093	.055	.036	.010	.003
4	0.390	1.65	Curdled	.056	.090	.055	.036	.010	.003
5	0.520	2.20	Not curdled	.059	.087	.056	.037	.011	.002
6	0.650	2.75	Not curdled	.064	.082	.061	.030	.011	.002
7	0.780	3.30	Not curdled	.069	.078	.061	.030	.011	.002
8	0.910	3.85	Not curdled	.072	.074	.062	.029	.012	.001
9	1.040	4.40	Not curdled	.075	.071	.064	.027	.012	.001

soluble calcium increases; (2) this increase is largely due to reaction of sodium citrate with the calcium caseinate in the milk, forming sodium caseinate or a double salt (calcium-sodium caseinate) and calcium citrate; and (3) use of increased amounts of sodium citrate lengthens the time required for the milk to curdle with rennet action or entirely prevents the curdling.

TABLE II.—EFFECT OF SODIUM CITRATE ON THE CURDLING OF MILK BY RENNIN.

No. of Experiment.	Grams of sodium citrate added to 100 c.c. of milk.	Equal to grains of sodium citrate in 1 ounce of milk.	Amount of rennet solution used per 100 c.c. of milk.	Minutes required for milk to curdle.
1.......	0.0	0.0	2	6
2.......	0.050	0.20	2	7½
3.......	0.100	0.40	2	8½
4.......	0.150	0.65	2	11
5.......	0.200	0.85	2	31
6.......	0.250	1.00	2	37
7.......	0.300	1.25	2	47
8.......	0.350	1.50	2	62
9.......	0.400	1.70	2	Not curdled
10.......	0.450	1.90	2	Not curdled
11.......	0.500	2.10	2	Not curdled

CONCLUSION.

Without going into full details, it will answer our purpose here to offer, on the basis of the facts developed, the following explanations as to why the presence of sodium citrate in milk delays or prevents curdling by rennin: Knowing the amount of soluble calcium formed by addition of sodium citrate to milk and knowing also the amount of casein present, we are able to ascertain that, at the point at which the rennet solution fails to curdle the milk, we have in place of the calcium caseinate of the normal milk a double salt, calcium-sodium caseinate. This double salt, on addition of rennin, forms a calcium-sodium paracaseinate containing one equivalent of sodium; and this compound, owing to the presence of the sodium, is not curdled by rennin. The increasing softness of the curd, accompanying the addition of increasing amounts of sodium citrate, is due to the presence of increasing amounts of calcium-sodium paracaseinate. A point is finally reached when all the calcium caseinate becomes calcium-sodium paracaseinate and the milk fails to curdle.

II. THE USE OF SODIUM CITRATE FOR THE DETERMINATION OF REVERTED PHOSPHORIC ACID.[1]*

ALFRED W. BOSWORTH.

In 1871, Fresenius, Neubauer and Luck [2] published a method for the determination of reverted phosphoric acid in phosphates which involves the use of a solution of neutral ammonium citrate, specific gravity 1.09. This method, with a change in the temperature of the solvent, has been in constant use since that time [3] with no attempt by any one to give an explanation of the chemical reaction involved. It has been quite generally believed that the neutral ammonium citrate solution possesses a selective power which enables it to separate dicalcic-phosphate from tricalcic-phosphate. This is not true, for it has been found in this laboratory that 100 c.c. of the official ammonium citrate solution [3] is capable of dissolving 1.3 grams of precipitated tricalcic-phosphate in one-half hour at a temperature of 65° C. This dissolving of the tricalcic-phosphate is accompanied by a precipitation of calcium citrate.

This separation of calcium citrate led to the belief that the solvent action of the citrate solution was the result of a double decomposition started by the free phosphoric acid always present in an aqueous solution which is in contact with a solid phase composed of a phosphate.[4] This double decomposition might be indicated by the following:

$$CaHPO_4 + 2C_6H_5O_6(NH_4)_3 \longrightarrow (NH_4)_2HPO_4 + [C_6H_5O_6(NH_4)_2]_2Ca$$
$$Ca_3P_2O_8 + 6C_6H_5O_6(NH_4)_3 \longrightarrow 2(NH_4)_3PO_4 + 3[C_6H_5O_6(NH_4)_2]_2Ca$$

If appreciable amounts of calcium are taken into solution, calcium citrate will separate out.

$$3[C_6H_5O_6(NH_4)_2]_2Ca \longrightarrow 4C_6H_5O_6(NH_4)_3 + (C_6H_5O_6)_2Ca_3$$

A great deal of work has been done upon methods of making neutral ammonium citrate solutions and several such methods have been published. The fact that neutral ammonium citrate is very unstable and easily loses ammonia has not been sufficiently considered in this connection, however. Why should extreme care be taken to secure an absolutely neutral solution, if this solution is to lose ammonia when heated a few degrees above the room temperature? Most chemists who have used the neutral ammonium citrate solution know that ammonia is constantly given off during the half hour allowed for the solvent action to take place. The final result then,

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[1] Read before the Association of Official Agricultural Chemists, Washington, D. C., Nov. 17, 1913, and published in the *Jour. Indust. Eng. Chem.*, **6** : 227.

[2] *Ztschr. Analyt. Chem.*, 10 : 133.

[3] U. S. Dept. Agr., Bur. of Chem., Bull. 107 (revised).

[4] Cameron and Hurst, *Jour. Amer. Chem. Soc.*, 26, 905.

* Reprint of part of Technical Bulletin No. 34, May; see p. 286.

is not the action of neutral citrate but rather the action of an acid citrate. There seemed to be no theoretical reason why a solution of sodium citrate should not be just as effective a solvent and it possesses two distinct advantages. It is a more stable salt and as the base in it is not volatile the solution would remain neutral throughout the whole operation. All trouble in securing a neutral solution would be eliminated, for a solution of citric acid could be neutralized with sodium hydroxide, using phenolphthalein as an indicator, or the neutral crystals of sodium citrate could be dissolved in water, and the solution made up to the required volume.

In order to learn what the action of a solution of sodium citrate might be, one was made which was of the same molecular concentration as the Official[1] ammonium citrate solution, *i. e.*, 314 grams crystallized sodium citrate, $(C_6H_5O_6Na_3)_2 \cdot 11\ H_2O$, per liter. This solution was used to determine the amounts of insoluble and reverted phosphoric acid in several fertilizers, Thomas slag, ground bone, ground rock phosphate, dicalcic-phosphate, $CaHPO_4$, and tricalcic-phosphate, $Ca_3P_2O_8$. The results, together with those obtained by the use of the Official citrate solution, are given in the table. In connection with these figures, it is noticeable that the differences between the figures obtained with the two solutions are, in most cases, of the same magnitude as the variations in the figures obtained by different chemists working upon the same sample.[2] It is also interesting to know that Samples 5, 10 and 11, which show the largest differences, all contain bone. The duplicate determinations, in all cases, showed closer agreement with sodium citrate solution than with the Official citrate solution.

The Official method directs that the flask in which the reaction takes place should be loosely stoppered, during the time it is being maintained at 65° C., in order to prevent evaporation. The use of stoppers often results in the loss of a determination through the breaking of a flask. It is suggested that the flask be closed with a one-hole rubber stopper carrying an empty calcium chloride tube, 300 mm. in length, which will serve as a condenser. The use of such a condenser will not interfere with the shaking and it furnishes a vent which prevents the breaking of the flask.

The last column of the table shows the amounts of ammonia given off during the half hour of treatment with ammonium citrate solution prescribed by the Official method. This ammonia was caught in standard acid by means of an air current which was passed through the Erlenmeyer flask in which the solvent action was taking place. These figures seem to bear some relation to the difference given in the preceding column. By noticing the large amounts of ammonia given off by the Thomas slag, rock phosphate and ground bone

[1] U. S. Dept. Agr., Bur. Chem. Bull. 107 (revised).

[2] *Jour. Indust. Eng. Chem.*, 3 : 118 and 5 : 957. The differences between the extremes in these two cases are 1.23 per ct. and 0.90 per ct. respectively.

when treated with ammonium citrate at 65° C. for one-half hour an indication as to the reason for the liberation of the ammonia may be found. The fertilizing materials, after being extracted with water, leave a residue which, in most cases, contains alkaline material, alkaline phosphates, carbonates of calcium and magnesium and oxides of other elements. These all tend to drive off ammonia from the citrate solution.

Table III.—Comparison of the Use of Ammonium Citrate and Sodium Citrate for the Determination of Reverted Phosphoric Acid.

	Total P_2O_5.	Water-soluble P_2O_5.	By Ammonium Citrate.		By Sodium Citrate.		Difference.	Cc. of N/10 NH_3 liberated in ½ hour at 65° C.
			Insol. P_2O_5.	Reverted P_2O_5.	Insol. P_2O_5.	Reverted P_2O_5.		
1	10.63	6.18	1.75	2.76	2.61	1.84	0.91	14.9
2	8.73	3.76	1.42	3.55	1.89	3.08	0.47	12.7
3	9.58	6.50	0.76	2.32	1.11	1.97	0.35	10.9
4	12.33	11.90	0.02	0.41	0.00	0.43	0.02	6.5
5	14.59	1.21	4.01	9.37	9.07	4.31	5.06	12.5
6	10.92	3.76	0.58	6.58	1.11	6.05	0.53	13.5
7	11.18	8.73	0.34	2.11	0.66	1.79	0.32	16.0
8	9.61	4.24	1.62	3.75	2.80	2.57	1.18	14.2
9	7.31	0.95	2.59	3.77	4.58	1.78	1.99	10.5
10	8.79	0.00	5.22	3.57	7.78	1.01	2.56	29.0
11	19.91	1.84	6.34	11.73	14.89	3.18	8.55	23.0
12	13.07	8.42	0.22	4.43	0.77	3.88	0.55	13.5
13	11.69	4.33	3.68	3.68	4.15	3.21	0.47	16.9
Bone	20.95	0.00	13.36	7.59	15.82	5.13	2.46	14.0
Slag	17.57	0.00	9.40	8.17	15.69	1.88	6.29	65.0
Rock phosphate	29.72	0.19	27.57	1.96	28.20	1.33	0.63	20.5
$CaHPO_4$ 1 gram taken		......	0.00	......	0.00	......	0.00	3.5
$Ca_3P_2O_8$ 1 gram taken		......	0.00	......	0.00	......	0.00	14.0
Ammonium citrate heated to 65° C				......	......	......	......	2.6
Ammonium citrate heated to 75° C				......	......	......	......	36.0

It is realized that the small amount of evidence presented in this paper does not settle the question as to the desirability of substituting sodium citrate for ammonium citrate in the determination of reverted phosphoric acid. The subject is simply brought forward at this time in order that those chemists who are interested may give it some thought.

STUDIES RELATING TO THE CHEMISTRY OF MILK AND CASEIN.*

SUMMARY.

I. The acidity of fresh milk is due to the presence of acid phosphates. Titration of phosphoric acid with alkali, in the presence of calcium salts, results in hydrolysis of dicalcium phosphate formed during the titration, whereby free calcium hydroxide and phosphoric acid are first formed and then calcium hydroxide unites with more dicalcium phosphate to form insoluble tricalcium phosphate. As a result of these reactions more alkali is required to make a solution, containing calcium and phosphoric acid, neutral to phenolphthalein than is required in the absence of calcium. The calcium must be removed previous to titration by treatment of 100 c.c. of milk with 2 c.c. of saturated solution of neutral potassium oxalate.

II. The amount of phosphorus in casein has been commonly given as about 0.85 per ct. By treating a solution of casein in dilute NH_4OH with ammonium oxalate and an excess of NH_4OH and letting stand 12 hours the phosphorus content is reduced to about 0.70 per ct. This lower percentage can not be explained as being due to hydrolysis of casein and splitting off of phosphorus. While some of the casein is hydrolyzed, this portion does not enter into the final preparation and does not affect its composition, because the hydrolyzed portion is not precipitated by acetic acid while the unhydrolyzed part is. The higher figure ordinarily given is due to the presence of inorganic phosphorus (dicalcium phosphate) carried from the milk into the precipitated casein and not entirely removed under the usual conditions of preparation. The lower figure corresponds very closely to two atoms of phosphorus (0.698 per ct.) in the casein molecule. Analyses of various preparations of casein containing varying amounts of ash show a general correspondence between the ash and phosphorus content.

III. The similarity between the composition of casein and paracasein, and the fact that casein has been shown to have a molecular weight of 8888 + and a valency of 8, while paracasein has been shown to have a molecular weight of 4444 + and a valency of 4,[1] seems to be evidence enough for concluding that the transformation of casein into paracasein is a process of hydrolytic splitting, one

[1] Van Slyke and Bosworth. N. Y. Agrl. Expt. Sta. Tech. Bull. No. 26, and *Journ. Biol. Chem.*, 14:227.

* Reprint of Technical Bulletin No. 37, December.

molecule of casein yielding two molecules of paracasein, and that this splitting of casein is not accompanied by a cleavage of any of the elements contained in the original casein molecule.

I. THE CAUSE OF ACIDITY OF FRESH MILK OF COWS AND A METHOD FOR THE DETERMINATION OF ACIDITY.

LUCIUS L. VAN SLYKE AND ALFRED W. BOSWORTH.

INTRODUCTION.

The usual method employed in determining the acidity of milk is to add a few drops of a solution of phenolphthalein as indicator to 100 c.c. of milk and then titrate with $\frac{N}{10}$ NaOH. By the use of this method it is found that 100 c.c. of milk, when strictly fresh, will require the addition of 15 to 20 c.c. of the alkali in order to produce a faint but permanent pink coloration.

The acidity of fresh milk has been commonly attributed to the presence of acid phosphates and casein, and we will now consider the relation of these constituents to milk acidity.

That the acidity of milk is due to the presence of acid phosphates (MH_2PO_4) is indicated by the fact that milk is strongly alkaline to methyl orange. Further, it is well known that phosphates can not be titrated with any degree of accuracy in the presence of calcium salts, due to the fact that some of the insoluble dicalcium phosphate ($CaHPO_4$), which is formed during the titration, hydrolyzes, changing into calcium hydroxide and phosphoric acid, and then the calcium hydroxide unites with more dicalcium phosphate, forming tricalcium phosphate ($Ca_3P_2O_8$).[2] These facts may be represented by the following equations:

$$(1)\quad CaHPO_4 + 2\,H_2O \rightleftarrows Ca(OH)_2 + H_3PO_4$$

$$(2)\quad 2\,CaHPO_4 + Ca(OH)_2 \rightarrow Ca_3P_2O_8 + 2\,H_2O.$$

That tricalcium phosphate is formed during the titration of any solution containing phosphoric acid and calcium salts is easily demonstrated by an anlysis of the precipitate always appearing; this precipitate is tricalcium phosphate, which is characterized by its appearance, varying from a flocculent to a gelatinous condition according to the concentration of the calcium and phosphates in the solution.

Dibasic phosphates are neutral to phenolphthalein and monophosphates are acid to this indicator; phosphoric acid, therefore, acts as a diabasic acid to phenolphthalein. In the reaction represented above, we have, in place of the original molecule of neutral dicalcium phosphate, one molecule of free phosphoric acid, whereby

[2] Cameron and Hurst. *Journ. Amer. Chem. Soc.*, 26: 905. 1904.

the acidity as measured by titration is increased over what it would be if no such reaction occurred. These facts serve to explain some results obtained by us in connection with the study of certain problems relating to milk.

We have found that when we titrate whole milk with alkali, in the usual way and then similarly titrate the serum obtained by filtering the milk through a porous procelain filter, the titration figure given by the whole milk is about double that obtained with the serum. For example, 100 c.c. of whole milk may show an acidity of 17 c.c. of $\frac{N}{10}$ alkali, and 100 c.c. of serum, 8 c.c. This difference has ordinarily been interpreted as being due to the acidity of milk casein, but in a future paper we shall show that casein is present in fresh milk as a calcium caseinate that is neutral to phenolphthalein. The other constituents removed from the milk by filtering through porous porcelain are fat and dicalcium phosphate, both of which are also neutral to phenolphthalein. From the illustration given above, the titration figure of the residue on the filter would appear to be 9 (17–8) for 100 c.c. of milk, though in reality the reaction is neutral. We believe that the cause of this discrepancy is to be found in the dicalcium phosphate which is present in the whole milk but which is not present in the serum. Its presence in the milk permits the formation of relatively large amounts of phosphoric acid and tricalcium phosphate, requiring the use of the increased amounts of $\frac{N}{10}$ alkali (17 c.c.) to neutralize the milk, as compared with the amount (8 c.c.) needed to neutralize the serum. We have been led by such results to believe that the acidity of milk, as usually determined, is about twice what it should be.

The disturbing influence of calcium salts in the presence of phosphates has been studied by Folin [3] in connection with the determination of acidity in urine; he was able largely to overcome the difficulty by the addition of neutral potassium oxalate, by which the calcium is removed in the form of the insoluble oxalate. He showed that by this preliminary treatment correct titration figures could be obtained for monocalcium phosphate which, without such treatment, gives figures that are remote from the calculated acidity.

METHOD FOR DETERMINING THE ACIDITY OF MILK.

Making use of Folin's procedure, and, before titrating with alkali, adding to milk some saturated solution of neutral potassium oxalate, we are able to obtain figures which conform more closely to the results indicated as accurate by other considerations.

The method, as modified by us for the determination of acidity in milk, whether fresh or otherwise, is as follows:

Measure 100 c.c. of milk into a 200 c.c. Erlenmeyer flask, add 50

[3] *Amer. Journ. of Physiol.*, 9:265. 1903.

c.c. of distilled water and 2 c.c. of a saturated solution of neutral potassium oxalate, allow the mixture to stand not less than two minutes and then titrate with $\frac{N}{10}$ NaOH. Since most solid potassium oxalate is acid, care must be taken to prepare a solution that is really neutral, which may be done in the following way: A saturated solution of ordinary potassium oxalate is prepared and decanted from the solid residue. To this solution is added 1 c.c. of phenolphthalein solution and then, drop by drop, enough normal NaOH solution to produce a permanent faintly pink coloration.

In the following table is given the acidity of 21 samples of milk from individual cows, as determined by the two methods, with and without addition of neutral potassium oxalate.

Number of sample.	Amount of $\frac{N}{10}$ NaOH required to neutralize 100 c.c. of milk.	
	Before addition of neutral potassium oxalate.	After addition of neutral potassium oxalate.
	c.c.	*c.c.*
1	15	6.4
2	15.2	7.0
3	15.6	6.8
4	16.0	6.8
5	17.0	8.0
6	17.0	8.0
7	17.2	8.0
8	17.6	9.0
9	17.8	8.8
10	18.0	9.0
11	18.2	9.6
12	18.4	9.6
13	18.4	9.4
14	18.6	9.4
15	18.6	9.4
16	19.0	9.4
17	19.2	10.0
18	19.4	10.4
19	20.0	9.8
20	22.0	12.8
21	23.8	14.0

Potassium oxalate is a poisonous substance. If the method as outlined above is used for the determination of the acidity of milk, extreme care should be taken to see that the potassium oxalate solution is kept in a bottle properly labeled and marked with the word POISON.

II. THE PHOSPHORUS CONTENT OF CASEIN.

ALFRED W. BOSWORTH AND LUCIUS L. VAN SLYKE.

INTRODUCTION.

In a previous paper[4] from this laboratory, a method has been described for preparing casein practically ash-free, the last portion of calcium being removed by treating a solution of the casein in dilute NH_4OH with ammonium oxalate and excess of NH_4OH, and then allowing the mixture to stand about twelve hours. Casein thus prepared contains about 0.71 per ct. of phosphorus. The accuracy of this figure has been questioned,[5] because it is considerably lower than that (about 0.85 per ct.) hitherto commonly accepted as correct. The suggestion has been made that the lower figure is due to the splitting off of phosphorus from the casein molecule as the result of hydrolysis caused by prolonged contact with NH_4OH.

It is the purpose of this paper to present the results of an experimental study relating to the effects of partial hydrolysis of casein on the phosphorus content of casein preparations and also to offer an explanation as to why the higher figures that have been usually reported for the percentage of phosphorus in casein are not correct.

In connection with investigations recently carried on in this laboratory, the results of which have not yet been published, certain facts have been developed which appear to explain why the high figure usually accepted for the phosphorus content of casein is inevitably obtained in consequence of the method employed in making casein preparations. Two of the constituents of cow's milk are present in the form of colloidal solution, calcium caseinate and dicalcium phosphate. These two compounds appear to have a strong attraction for each other, as shown by the fact that, when casein is separated from milk by means of either centrifugal force or precipitation with a dilute acid, the casein always carries with it more or less dicalcium phosphate. It is evident, then, that in preparing casein by the usual method in which care is taken to avoid an excess of both acid and alkali, it is practically impossible to remove this phosphate completely. In order, therefore, to ascertain the true phosphorus content of casein, it is obviously necessary that the preparation be free from inorganic phosphorus and this can be accomplished only by removing all of the calcium. Several methods have been tried in this laboratory to effect this, and the one finally found to be the most satisfactory is that described in a previous paper, referred to above.

[4] N. Y. Agrl. Expt. Sta. Tech. Bull. No. 26, and *Journ. Biol. Chem.* 14:203. 1913.

[5] Harden and Macallum. *Biochem. Journ.* 8:90.

Further, a good reason for believing that the lower figure more closely approximates the truth than the higher one hitherto commonly accepted as correct is the relation of phosphorus to the molecular weight of casein. In a previous paper[6] it was shown that the molecular weight of casein is approximately 8888. Now, if the casein molecule contains two atoms of phosphorus, the percentage of phosphorus is 0.698, while the phosphorus content would be 1.046 per ct. if there were three atoms of phosphorus. The figure (0.85 per ct.) heretofore regarded as correct represents, therefore, on account of the presence of impurities in the preparation, neither two atoms nor three atoms of phosphorus, while the lower figure (0.71 per ct.) represents almost exactly two atoms.

Coming now to the criticism made that an excess of NH_4OH in contact with casein for twelve hours causes hydrolysis, resulting in the formation of inorganic phosphorus, there is reason to believe that, whatever hydrolysis takes place, it does not necessarily interfere with the composition of the final preparation, because, as will be shown, the products of hydrolysis are not precipitated by dilute acetic acid and therefore form no part of the completed preparation which is pure, unhydrolyzed casein.

EXPERIMENTAL.

After giving the ash and phosphorus content of several preparations of casein, we will present the results of a study of two special preparations of casein which were subjected to varying conditions in order to ascertain whether hydrolysis affects the phosphorus content of casein preparations.

Ash content and phosphorus content of casein.—The percentages of ash and phosphorus in five samples of casein prepared in this laboratory during the past seven or eight years are as follows:

SAMPLE.	Ash.	Phosphorus.
	Per ct.	*Per ct.*
1	0.06	0.710
2	0.39	0.732
3	0.61	0.830
4	0.61	0.839
5	3.93	0.941

The results show that increase of ash is accompanied by an increase of phosphorus.

[6] N. Y. Agrl. Expt. Sta. Tech. Bull. No. 26, and *Journ. Biol. Chem.*, 14:228. 1913.

Phosphorus content of casein preparations treated in different ways. In order to study the effect of treating casein in different ways upon the content of phosphorus, and especially to ascertain what effect partial hydrolysis may have upon the phosphorus content of casein preparations, two preparations of casein were made and each of these was treated in the manner described below.

Preparation A was made in the usual way, treating alternately with dilute acetic acid and ammonia, avoiding an excess of each reagent. This preparation contained 0.857 per ct. of phosphorus.

Preparation B was made according to the method given in a previous paper,[7] the distinctive feature of which is treatment of a solution of casein in dilute alkali with ammonium oxalate and excess of alkali. This preparation contained 0.711 per ct. of phosphorus.

(1) Treatment with excess of ammonia. Each of preparations A and B (20 grams) was dissolved in dilute NH_4OH and an excess of the same reagent was added; after standing twelve hours at 37° C., the solution was centrifugalized and filtered, the casein in the filtrate being then precipitated with dilute acetic acid. This precipitated casein was washed, redissolved, reprecipitated and finally washed with water, alcohol and ether.

In the case of preparation A, the yield was 14 grams, containing 0.841 per ct. of phosphorus; in the case of preparation B, the yield was 15 grams and the phosphorus content 0.713 per ct.

The decreased yield in each case was due in part to hydrolysis of casein and in part to mechanical losses. It is evident that partial hydrolysis of casein preparations has no effect on the percentage of phosphorus in the unhydrolyzed casein that is recovered.

(2) Treatment with ammonium oxalate and excess of ammonia. Each of preparations A and B (20 grams) was dissolved in dilute NH_4OH and then ammonium oxalate and an excess of NH_4OH added, the mixture being allowed to stand twelve hours at 37° C. The casein was separated as before.

In the case of preparation A, the yield was 14 grams, containing 0.723 per ct. of phosphorus; in the case of preparation B, the yield was 14.5 grams, containing 0.71 per ct. of phosphorus.

In these two experiments, hydrolysis of casein by alkali has no effect upon the percentage of phosphorus in the casein finally recovered. In the case of preparation A, the phosphorus content is reduced from 0.857 to 0.723 per ct., as a result of the removal of calcium phosphate from the casein preparation. In the case of preparation B, the phosphorus content remains the same as in the original preparation, because the casein used had already been subjected to treatment with ammonium oxalate and excess of

[7] Loc. cit.

NH_4OH, the calcium phosphate having been removed as completely as practicable.

(3) Treatment as in (2) but prolonged. Preparation B (20 grams) was treated as in the preceding experiment, except that the mixture was allowed to stand seventy-two hours (instead of twelve) at 37° C. The amount of casein recovered was 12.4 grams containing 0.721 per ct. of phosphorus. The prolonged treatment, giving opportunity for increased hydrolysis of casein, did not change the percentage of phosphorus in the casein recovered.

III. THE ACTION OF RENNIN ON CASEIN.

(Second paper.)

ALFRED W. BOSWORTH.

INTRODUCTION.

In order to determine if the change from casein to paracasein results in the cleavage of any of the elements contained in the casein molecule it is imperative that pure casein be used as a standard of comparison, and that the rennin activity be positively differentiated from any further proteolytic activity of the enzyme under consideration, for it is quite evident that "Rennin action is probably a hydrolytic cleavage and may be considered the first step in the proteolysis of casein. It would follow from this that the action now attributed to rennin may be produced by any proteolytic enzyme."[8]

EXPERIMENTAL.

Pure casein and paracasein were prepared according to the methods previously published.[9] Pure paracasein was also prepared by allowing trypsin to act upon fat-free milk after the addition of calcium chloride, and the curd produced was purified according to the method referred to. The use of an excess of ammonia as prescribed has been criticised by Harden and Macallum[10] who claim that preparations made in that way may have a low phosphorus content due to the cleavage of phosphorus from the casein molecule by the action of the ammonia. In the preceding paper it has been shown that this criticism does not hold. The analyses of the preparations are given in the table.

[8] Bosworth. N. Y. Agrl. Expt. Sta. Tech. Bull. No. 31; also *Journ. Biol. Chem.* **15**:236.

[9] Van Slyke and Bosworth. N. Y. Agrl. Expt. Sta. Tech. Bull. No. 26; also *Journ. Biol. Chem.* **14**:203.

[10] Harden and Macallum. *Biochem. Journ.* 8:90.

	Casein.	Paracasein by rennin.	Paracasein by trypsin.
Moisture	1.09	1.63	1.27
Carbon in dry substance	53.50	53.50	53.47
Hydrogen in dry substance	7.13	7.26	7.19
Oxygen in dry substance	*22.08	*21.94	*22.04
Nitrogen in dry substance	15.80	15.80	15.78
Phosphorus in dry sybstance	0.71	0.71	0.71
Sulphur in dry substance	0.72	0.72	0.72
Ash in dry substance	0.06	0.07	0.09

* By difference.

These figures show that the composition of paracasein is the same irrespective of the enzyme used to produce it. The figures also show that casein and paracasein have the same percentage composition, which excludes the possibility that cleavage of any of the elements of casein is a result of its transformation into paracasein by enzymes.

Harden and Macallum, in their paper, conclude that "The conversion of caseinogen into casein by enzyme action is accompanied by the cleavage of nitrogen, phosphorus and calcium.[11]" It seems more probable to us that this cleavage follows rather than accompanies the conversion in question, and is to be attributed to a continuation of proteolytic activity by the enzyme beyond the point where casein has been changed to paracasein. This point was emphasized in my first paper on the action of rennin on casein.[12]

[11] The English caseinogen is equivalent to the American casein. The English casein is equivalent to the American paracasein.

Harden and Macallum give the nitrogen-phosphorus ratio of casein as N : P = 100 : 5.6. The high phosphorus content of their casein preparations [0.87 to 0.90 per ct.] would seem to indicate the presence of considerable inorganic phosphorus. If our figures are correct for the nitrogen and phosphorus content of casein [15.80 per ct. N, 0.71 per ct. P] the ratio would be N : P = 100 : 4.50. In only one of their experiments conducted to show the loss of phosphorus from the casein molecule was the N-P ratio reduced to 4.50.

[12] Bosworth. N. Y. Agrl. Expt. Sta. Tech. Bull. No. 31; also *Journ. Biol. Chem.* **15**:231.

CONDITION OF CASEIN AND SALTS IN MILK.*

LUCIUS L. VAN SLYKE AND ALFRED W. BOSWORTH.

SUMMARY.

1. Milk contains two general classes of compounds, those in true solution and those in suspension, or insoluble. These two portions can be separated for study by filtering the milk through a porous earthenware filter like the Pasteur-Chamberland filtering tube.

2. Serum prepared from fresh milk is yellow with a faint greenish tinge and slight opalescence. The following constituents of milk are wholly in solution in the milk-serum: Sugar, citric acid, potassium, sodium and chlorine. The following are partly in solution and partly in suspension: Albumin, inorganic phosphates, calcium, magnesium. Albumin in fresh milk appears to be adsorbed to a considerable extent by casein and therefore only a part of it appears in the serum. In serum from sour milk and milk to which formaldehyde has been added, nearly all of the albumin appears in the serum.

3. The insoluble portion of milk separated by filtration through the Pasteur-Chamberland filtering tube is grayish to greenish white in color, of a glistening, slime-like appearance and gelatinous consistency. When shaken with water it goes readily into suspension, forming a mixture having the opaque, white appearance of milk. Such a suspension is neutral to phenolphthalein. When purified, the insoluble portion consists of neutral calcium caseinate (casein Ca_4) and neutral di-calcium phosphate ($CaHPO_4$). The casein and di-calcium phosphate are not in combination, as shown by a study of 16 samples of milk from 13 individual cows, and also by a study of the deposit or " separator slime " formed by whirling milk in a cream separator. By treating fresh milk with formaldehyde and whirling in a centrifugal machine under specified conditions, it is possible to effect a nearly complete separation of phosphates from casein.

4. Both fresh milk and the serum from fresh milk show a slight acid reaction to phenolphthalein but are strongly alkaline to methyl orange, indicating that acidity is due, in part at least, to acid phosphates. In 8 samples of fresh milk, the acidity of the milk and of the milk-serum was determined after treatment with neutral potassium oxalate. The results show that that acidity of the whole milk is the same as that of the serum and that, therefore, the con-

* Reprint of Technical Bulletin No. 39, December.

stituents of the serum are responsible for the acidity of milk. There is every reason to believe that the phosphates of the serum cause the observed acidity.

5. The data presented, with results of other work, furnish a basis for suggesting an arrangement of the individual compounds contained in milk, especially including the salts.

INTRODUCTION.

The chemistry of milk has been studied by many investigators. Numerous facts have been accumulated relating to the amounts and properties of the more prominent constituents of milk, including various conditions affecting the composition; but much less attention has been given to thorough study of individual constituents, owing largely to the difficulties involved in making such investigations.

From the beginning of its existence, this Station has given much attention to study of different phases of the composition of milk. In connection with the study of the relation of the constituents of milk to cheese-making, to fermented beverages made from milk, and to the uses of milk in human nutrition, numerous chemical questions have constantly arisen and continue to come up, to which satisfactory answers can not be given, owing to our lack of knowledge of the chemistry of some of the milk constituents. Until our knowledge in this field becomes more complete, we cannot understand fully, for example, the fundamental chemical facts involved in the process of cheese-making and cheese-ripening, the chemical changes taking place in its constituents when milk sours or when it is made into fermented beverages such as kumyss, imitation buttermilks, matzoon, zoolak, bulgarzoon, etc.

We have in hand investigations relating to several of the fundamental questions referred to. In the present bulletin, we shall present the results of our work bearing on the following points:

(1) Properties and composition of milk serum or constituents in solution.

(2) Properties and composition of portion of constituents not in solution.

(3) Acidity of milk and milk-serum.

(4) The salts of milk.

METHOD OF PREPARING MILK-SERUM.

Before taking up the detailed results relating to these lines of investigation, we will give a description of the method used in preparing milk-serum from milk.

That portion of the milk consisting of water and the compounds in solution is known as the milk-serum. In studying the individual constituents of milk, it is necessary to separate the serum. Various methods have been used to separate milk-serum from the other con-

stituents of milk, but the one best adapted for investigational purposes depends upon the fact that when milk is brought into contact with a porous earthenware filter, the water passes through, carrying with it the compounds in true solution, while the compounds insoluble in water or in suspension remain on the surface of the filter. In one form or another, this fact has been utilized in studying milk by Lehman, Duclaux, Eugling, Söldner and others. The form of earthenware filter used by us is much superior to any employed by these investigators. We have made use of the special form of apparatus designed by Briggs[1] for the purpose of obtaining water-extracts from soils. Briefly stated, the process consists in putting the milk to be examined into a tubular chamber surrounding a Pasteur-Chamberland filtering tube; pressure, amounting to 40 to 45 pounds per square inch, is applied by means of a pump which forces air into the chamber containing the milk and causes the soluble portion of the milk to pass through the walls of the filter from the outside to the inside of the filtering tube, from which it runs out and is caught in a flask standing underneath. The insoluble residue accumulates on the outside surface of the filter tube from which it can easily be removed by light scraping.

It has been found by Rupp[2] that the filter appears to have the power of absorbing some of the soluble constituents of the serum until a volume of 50 to 75 c.c. has passed through, after which the filtered serum is constant in composition. In our work, therefore, the first portion of serum filtered is not used.

Before being placed in the apparatus for filtration, the milk is treated with some antiseptic to prevent souring during the process of filtration.

The composition of the solid portion of milk removed by the filtering tube is ascertained by difference; from the figures obtained by an analysis of the original milk we subtract the results of analysis given by the serum.

PROPERTIES AND COMPOSITION OF MILK-SERUM.

Serum prepared from fresh milk by the method described above has a characteristic appearance, being of a yellow color with a faint greenish tinge and slight opalescence.

The serum from fresh milk gives a slight acid reaction to phenolphthalein and a strongly alkaline reaction to methyl orange. We will later give the results of a special study made of the cause of acidity in milk-serum.

In the table below we give the results of the examination of two samples of fresh milk, the serum of which was prepared in the manner already described. These samples of milk were treated with chloro-

[1] U. S. Dept. Agr. Soils. Bul. 19, p. 31, and Bul. 31, pp. 12-16.
[2] U. S. Dept. Agr. An. Ind. Bul. 166, p. 9.

form at the rate of 50 c.c. per 1000 c.c. of milk and the fat removed by means of a centrifugal machine; the removal of fat is necessary since it clogs the pores of the filter. The fat-free milk was then filtered through Pasteur-Chamberland filtering tubes. Analyses were made of the milk and of the serum. We did not determine those constituents present in milk only in traces, such as iron, sulphuric acid, etc.

TABLE I.— CONSTITUENTS OF MILK-SERUM.

CONSTITUENTS.	SAMPLE NO. 1.			SAMPLE NO. 2.		
	Original milk 100 c.c.	Milk-serum 100 c.c.	Percentage of milk constituents in serum.	Original milk 100 c.c.	Milk-serum 100 c.c.	Percentage of milk constituents in serum.
	Grams.	*Grams.*	*Per ct.*	*Grams.*	*Grams.*	*Per ct.*
Sugar	......	......	......	5.75	5.75	100.00
Casein	3.35	0.00	0.00	3.07	0.00	0.00
Albumin	0.525	0.369	70.29	0.506	0.188	37.15
Nitrogen in other compounds	......	......	......	0.049	0.049	100.00
Citric acid	......	......	......	0.237	0.237	100.00
Phosphorus (organic and inorganic)	0.125	0.067	53.60	......	......	......
Phosphorus (inorganic)	0.096	0.067	70.00	0.087	0.056	64.40
Calcium	0.128	0.045	35.16	0.144	0.048	33.33
Magnesium	0.012	0.009	75.00	0.013	0.007	53.85
Potassium } Sodium }	*0.354	*0.352	99.44	0.120	0.124	100.00
				0.055	0.057	100.00
Chlorine	0.081	0.082	100.00	0.076	0.081	100.00
Ash	......	......	......	0.725	0.400	55.17

* As chlorides

A study of the data contained in Table I enables us to show the general relation of the constituents of milk to the constituents of milk-serum. The following form of statement furnishes a clear summary of the facts.

1. Milk constituents in true solution in milk serum:

(a) Sugar.
(b) Citric acid
(c) Potassium.
(d) Sodium.
(e) Chlorine.

2. Milk constituents partly in solution and partly in suspension or colloidal solution:

(a) Albumin.
(b) Inorganic phosphates.
(c) Calcium.
(d) Magnesium.

3. Milk constituents entirely in suspension or colloidal solution:

(a) Fat.
(b) Casein.

The behavior of milk albumin attracts special attention on account of marked lack of regularity in the results obtained. We commonly think of milk albumin as readily and completely soluble in water, and the question is therefore raised as to why a considerable portion of it does not pass through the Pasteur-Chamberland filter. In view of all the facts available, the most probable explanation that has so far suggested itself is that in fresh milk a part of the albumin is held by the adsorbing power of casein. This suggestion is supported by results obtained in the following experiments: Serum was prepared from chloroformed fresh milk treated in different ways. In the first experiment, serum direct from the fresh milk was compared with serum obtained from whey which had been obtained from another portion of the same milk by treatment with rennet-extract. In the second experiment, serum direct from fresh milk was compared with (a) serum obtained from another portion of the same milk after souring, and (b) serum obtained from another portion of the same milk to which some formaldehyde solution had been added. Albumin was determined in each case by boiling after addition of acetic acid, following the details given in the provisional method of the Association of Official Agricultural Chemists. The results of the experiments are given below.

	Albumin per 100 c.c. *Grams.*	Albumin of milk recovered in serum. *Per ct.*
First Experiment.		
Fresh milk	0.312	......
Serum from fresh milk	0.143	45.83
Serum from whey	0.187	59.94
Second Experiment.		
Fresh milk	0.266	......
Serum from fresh milk	0.148	55.64
Serum from sour milk	0.253	95.11
Serum from milk plus formaldehyde	0.245	92.21

In the first experiment it is seen that when casein is precipitated by rennet solution the curd (the precipitated casein or paracasein) carries down part of the albumin with it; the amount thus carried down is approximately equal in this case to that retained along with the casein on the external surface of the Pasteur-Chamberland filtering tube, when whole milk is filtered through such a filter.

In the second experiment we see that when the casein is precipitated with acid, as in the case of natural souring, the adsorbing action of

the casein is practically prevented and little or no albumin is carried down with it. In the case of the addition of formaldehyde to milk, the adsorbing power of casein is greatly diminished, probably due to the chemical reaction between casein and formaldehyde.

PROPERTIES AND COMPOSITION OF PORTION OF MILK IN SUSPENSION OR COLLOIDAL SOLUTION.

Some of the constituents of milk are suspended in the form of solid particles in such an extremely fine state of division that they pass through the pores of filter paper and they do not settle as a sediment on standing, but remain permanently afloat. They can not be seen except by ultra-microscopic methods. When substances are in such a condition, they are said to form a colloidal solution. In passing milk through the Pasteur-Chamberland filtering tube, the constituents in suspension as solid particles, and in colloidal solution, are retained in a solid mass on the outside of the tube and can therefore be readily obtained for study.

(1) *Appearance.*— When prepared by the method of filtration previously described, the insoluble portion of milk collecting on the outside of the filtering tube is grayish to greenish white in color, of a glistening, slime-like appearance and gelatinous consistency. When dried without purification by treatment with alcohol, etc., it resembles in appearance dried white of egg.

(2) *Behavior with water.*—The deposit of insoluble milk-constituents on the outside of the filtering tube, when removed and shaken vigorously in a flask with distilled water, goes into suspension and the mixture has the opaque, white appearance of the original milk. The deposit is, of course, more or less mixed with adhering soluble constituents but can be readily purified by shaking with distilled water and filtering several times. The purified material goes readily into suspension on shaking with water and, if treated with a preservative, will remain indefinitely without change other than the separation of fat-globules. It has been held by some that the citrates of milk perform the function of holding the insoluble phosphates in suspension, but this is not supported by the behavior of the insoluble portion shown in our experiments.

(3) *Reaction.*— A suspension of the insoluble constituents of milk, prepared in the manner described above, is neutral to phenolphthalein. We purified the deposit made from 1000 c.c. of milk, made a suspension of it in water, and, after the addition of 10 c.c. of neutral solution of potassium oxalate, it was found to require only 0.5 c.c. of $\frac{N}{10}$ solution of sodium hydroxide to make it neutral to phenolphthalein. We interpret this to mean that there are no tri-basic (alkaline) phosphates in milk or in the serum, because the serum,

since it is acid, can contain none, and the insoluble portion, being neutral, can therefore contain none.

(4) *Relation of inorganic constituents to casein in milk.*— Without going into a detailed discussion of the history of the different views held by different investigators, it is sufficient for our purpose to state that three general views have been put forward in regard to the relation of inorganic constituents to casein in milk: (1) That milk-casein is combined with calcium (about 1.07 per ct.) to form a salt, calcium caseinate (which is neutral to litmus and acid to phenolphthalein); (2) that casein is chemically combined directly with calcium phosphate; (3) that casein is a double compound consisting of calcium caseinate combined with calcium phosphate.

We have attempted to learn what is the true condition of casein in milk in relation to inorganic constituents, whether it is in combination with calcium alone or with some other inorganic base in addition and also whether milk-casein is an acid salt or a neutral salt and, further, whether the insoluble phosphates are in combination with casein or not.

In studying this problem, we will first give results of work done with 16 samples of fresh milk from 13 individual cows. Determinations were made of (a) casein, (b) total phosphorus, (c) soluble phosphorus, (d) insoluble phosphorus (b minus c), (e) insoluble organic phosphorus (0.71 per ct. of the casein), (f) insoluble inorganic phosphorus (d minus e), (g) total calcium, (h) soluble calcium,

TABLE II.— AMOUNTS OF PROTEINS, CASEIN, AND PHOSPHORUS IN MILK.

Cow No.	Stage of lactation	Total proteins.	Casein.	PHOSPHORUS.					Ratio of organic to insoluble inorganic phosphorus.
				Total.	Soluble.	INSOLUBLE.			
						Total.	Organic (in casein).	Inorganic (phosphates)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	Org. P. : In. P.
1.......	3 days..	4.35	3.48	0.1272	0.0818	0.0454	0.0247	0.0207	1 : 0.83
2.......	1 mo...	3.31	2.73	0.1150	0.0595	0.0555	0.0194	0.0361	1 : 1.86
3.......	1 " ...	3.53	2.78	0.1010	0.0494	0.0516	0.0197	0.0319	1 : 1.62
3.......	11 " ...	4.91	4.09	0.1111	0.0536	0.0575	0.0290	0.0285	1 : 0.98
4.......	3 " ...	3.93	3.09	0.1278	0.0563	0.0715	0.0219	0.0496	1 : 2.26
5.......	3 " ...	3.45	2.88	0.0943	0.0475	0.0468	0.0204	0.0264	1 : 1.29
5.......	7 " ...	3.45	2.70	0.0870	0.0334	0.0536	0.0192	0.0344	1 : 1.79
6.......	5 " ...	4.05	2.92	0.1008	0.0356	0.0652	0.0207	0.0445	1 : 2.15
7.......	6 " ...	4.07	3.40	0.1063	0.0548	0.0515	0.0241	0.0274	1 : 1.14
7.......	10 " ...	4.80	3.56	0.1010	0.0340	0.0670	0.0253	0.0417	1 : 1.65
8.......	7 " ...	4.39	3.58	0.1157	0.0550	0.0607	0.0254	0.0353	1 : 1.39
9.......	8 " ...	4.33	3.47	0.1036	0.0364	0.0672	0.0246	0.0426	1 : 1.73
10.......	9 " ...	3.65	3.10	0.1097	0.0610	0.0487	0.0220	0.0267	1 : 1.22
11.......	10 " ...	4.17	3.36	0.1090	0.0434	0.0656	0.0239	0.0417	1 : 1.74
12.......	11 " ...	4.35	3.14	0.1060	0.0286	0.0774	0.0223	0.0551	1 : 2.47
13.......	12 " ...	5.71	4.97	0.1310	0.0442	0.0868	0.0353	0.0515	1 : 1.46

(i) insoluble calcium (g minus h), (j) total magnesium, (k) soluble magnesium, (l) insoluble magnesium (j minus k). The determinations of total phosphorus, total calcium and total magnesium were made with the normal or whole milk, while those of soluble phosphorus, soluble calcium and soluble magnesium were made with the serum obtained by filtering through Pasteur-Chamberland filtering tubes in the manner already described. The amount of organic phosphorus was found[3] by multiplying the percentage of casein by 0.0071. For convenience of reference, the analytical data are arranged in two tables, II and III.

The data in Table II afford a basis for ascertaining the quantitative relation between casein and the phosphates. If casein is chemically combined with phosphates in milk, there should be a fairly definite and uniform relation between these constituents in the insoluble portion of milk, or, stated in another way, the organic phosphorus of casein should show a somewhat uniform ratio to the insoluble inorganic or phosphate phosphorus. In column 10 of Table II are given the results of calculations based on our data, which show the amount of insoluble inorganic phosphorus for one part of organic (casein) phosphorus. It is seen that the ratio varies between the wide limits of 1:0.82 and 1:2.47. Even in the case of milk from the same animal at different stages of lactation, the proportional amount of inorganic phosphorus varies widely, as from 0.98 to 1.62 with cow No. 3, from 1.29 to 1.79 with cow No. 5, and from 1.14 to 1.65 with cow No. 7. The only conclusion furnished by these results is that there is no evidence of chemical combination between the casein and the phosphates of milk. Additional evidence in confirmation of the foregoing statement will be furnished later in connection with the discussion of another phase of the subject.

Another interesting point connected with insoluble phosphates and casein in milk is as to the exact compound of calcium phosphate and of calcium caseinate existing in the milk. Söldner's inferential statement that milk-casein is neutral calcium caseinate (containing about 1.07 per ct. of calcium), has been generally accepted, not so much because of positive proof but because of absence of any proof to the contrary. Regarding the form of the compound in which phosphates exist in milk, all three forms (mono-, di-, and tri-basic phosphates) have been thought to be present. The insoluble phosphates have been regarded as a mixture of di- and tri-calcium phosphates.

Bearing on this question, we present data embodied in the following tables, III and IV.

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[3] Bosworth and Van Slyke. N. Y. Agrl. Expt. Sta. Tech. Bul. 37 and *Jour. Biol. Chem.*, 19:67.

Table III.— Amounts of Calcium and Magnesium in Insoluble Portion of Milk.

Cow No.	Stage of lactation.	Calcium.			Magnesium.		
		Total. (11)	Soluble. (12)	Insoluble. (13)	Total. (14)	Soluble. (15)	Insoluble. (16)
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1.........	3 days..	0.1607	0.0734	0.0873	0.0156	0.0142	0.0013
2.........	1 mo...	0.1381	0.0511	0.0870	0.0136	0.0117	0.0019
3.........	1 " ...	0.1362	0.0544	0.0818	0.0180	0.0142	0.0038
3.........	11 " ...	0.1559	0.0534	0.1025	0.0170	0.0156	0.0014
4.........	3 " ...	0.1483	0.0343	0.1140	0.0184	0.0128	0.0056
5.........	3 " ...	0.1396	0.0531	0.0865	0.0156	0.0124	0.0032
5.........	7 " ...	0.1256	0.0454	0.0802	0.0147	0.0134	0.0013
6.........	5 " ...	0.1413	0.0373	0.1040	0.0160	0.0127	0.0033
7.........	6 " ...	0.1464	0.0526	0.0938	0.0144	0.0121	0.0023
7.........	10 " ...	0.1523	0.0450	0.1073	0.0177	0.0127	0.0050
8.........	7 " ...	0.1506	0.0439	0.1062	0.0153	0.0118	0.0035
9.........	8 " ...	0.1503	0.0440	0.1063	0.0171	0.0126	0.0045
10.........	9 " ...	0.1410	0.0543	0.0867	0.0168	0.0141	0.0027
11.........	10 " ...	0.1379	0.0357	0.1022	0.0168	0.0119	0.0049
12.........	11 " ...	0.1659	0.0414	0.1245	0.0191	0.0123	0.0068
13.........	12 " ...	0.2167	0.0669	0.1498	0.0236	0.0163	0.0073

The data in Table IV are derived by calculation from the figures given in Tables II and III for the purpose of reducing them to a uniform basis that permits us to make comparison more easily.

Table IV.— Amounts of Acids and Bases Expressed as Gram Equivalents.

Cow No. (1)	Casein as gram equivalents of octavalent acid. (2)	Insoluble inorganic phosphates as gram equivalents of di-basic acid. (3)	Sum of gram equivalents of casein and phosphates. (4)	Insoluble calcium as gram equivalents. (5)	Insoluble magnesium as gram equivalents. (6)	Sum of the insoluble calcium and magnesium as gram equivalents. (7)	Excess of insoluble base (+) or acid (—) as gram equivalents. (8)
1........	31.3×10^{-4}	13.1×10^{-4}	44.4×10^{-4}	43.6×10^{-4}	1.1×10^{-4}	44.7×10^{-4}	$+0.3 \times 10^{-4}$
2........	24.5 "	23.1 "	47.6 "	43.5 "	1.6 "	45.1 "	—2.5 "
3........	25.0 "	20.5 "	45.5 "	40.9 "	3.1 "	44.0 "	—1.5 "
3........	36.8 "	18.1 "	54.9 "	51.2 "	1.2 "	52.4 "	—2.5 "
4........	27.8 "	32.0 "	59.8 "	57.0 "	4.6 "	61.6 "	+1.8 "
5........	25.9 "	16.8 "	42.7 "	43.2 "	2.7 "	45.9 "	+3.2 "
5........	24.3 "	22.2 "	46.5 "	40.1 "	1.0 "	41.1 "	—5.4 "
6........	26.3 "	28.7 "	55.0 "	52.0 "	2.7 "	54.7 "	—0.3 "
7........	30.6 "	17.4 "	48.0 "	46.9 "	1.9 "	48.8 "	+0.8 "
7........	32.0 "	26.9 "	58.9 "	53.7 "	4.2 "	57.9 "	—1.0 "
8........	32.2 "	22.3 "	54.5 "	53.4 "	2.9 "	56.3 "	+1.8 "
9........	31.1 "	27.5 "	58.6 "	53.2 "	3.8 "	57.0 "	—1.6 "
10........	27.9 "	17.0 "	44.9 "	43.4 "	2.2 "	45.6 "	+0.7 "
11........	30.2 "	27.0 "	57.2 "	51.1 "	4.1 "	55.2 "	—2.0 "
12........	28.3 "	35.5 "	63.8 "	62.3 "	5.7 "	68.0 "	+4.2 "
13........	44.7 "	32.9 "	77.6 "	74.9 "	6.1 "	81.0 "	+3.4 "

In our previous work we have shown that 1 gram of uncombined casein combines with 9×10^{-4} gram equivalents of calcium to form a salt that is neutral to phenolphthalein.[4] In column 2 of Table IV we make use of this fact in calculating the acid equivalents of the casein as found in each sample. In column 3 of the same table, we calculate the acid equivalents of the insoluble inorganic phosphorus in each sample of milk (regarding phosphoric acid as a divalent acid and $CaHPO_4$ neutral to phenolphthalein). In column 4 are shown the sums obtained by adding the figures in columns 2 and 3 in case of each sample of milk. In columns 5 and 6 are given the combining equivalents of calcium and magnesium and in column 7 their sum for each sample of milk. If now we compare, in case of each milk, the figures contained in column 4 with those contained in column 7, we notice that they are in close agreement, the differences being shown in column 8. This agreement means that the quantitative relation between the bases (calcium and magnesium) and the acids (casein and phosphoric acid) is that required, theoretically, to give di-calcium phosphate with a trace of di-magnesium phosphate and calcium caseinate neutral to phenolphthalein, in which casein is combined with 8 equivalents of calcium (casein Ca_4). However, the same analytical figures can with equal correctness be interpreted to prove that the compounds are present as acid caseinate and tri-calcium phosphate.

In order to decide which of these sets of compounds is present in milk, we have tried to make a separation of the casein and insoluble phosphates. The above results, it will be remembered, are obtained by difference, the milk and serum being analyzed and the composition of the insoluble portion being determined by subtracting the latter results from the former. It seemed desirable to separate milk in large amounts so as to obtain the insoluble portion in quantity sufficient to purify and analyze. This was done in the following manner, several experiments being made. In the first experiment, 400 pounds of milk was run through a centrifugal cream separator 18 times and the deposit ("separator slime") collecting on the walls of the bowl was removed after the 1st, the 6th, the 12th and the 18th run. Each of these deposits was placed in a mortar and triturated with small amounts of 95 per ct. alcohol with the gradual addition of more alcohol. A point is reached when the whole mass becomes jelly-like, after which the addition of more alcohol causes the formation of a fine flocculent precipitate. (Care must be taken not to add the alcohol too rapidly, because then there is apt to be formed a tough, leathery mass, which can not be handled.) The precipitate is allowed to settle and, after decanting the supernatant liquid, is triturated with several successive portions of 95 per ct. alcohol, 99 per ct. alcohol, and finally ether. It is then dried

[4] N. Y. Agrl. Expt. Sta. Tech. Bul. No. 26, p. 12.

at 60° C. for a few hours, after which the drying is completed in a vacuum over sulphuric acid. The analytical results are given in the table following:

TABLE V.— COMPOSITION OF INSOLUBLE PORTION ("SEPARATOR SLIME") OF MILK.

Sample of deposit taken.	Casein.	Ash.	Total phosphorus.	Phosphorus in casein.	Phosphorus as phosphate.	Calcium.	Ratio of organic to insoluble inorganic phosphorus.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Org.P.* : *In.P.*
After 1st run...	86.31	10.43	2.182	0.621	1.561	3.386	1 : 2.51
After 6th run...	90.07	9.35	1.950	0.649	1.301	3.246	1 : 2.00
After 12th run..	90.84	9.53	2.011	0.645	1.366	3.343	1 : 2.11
After 18th run..	91.98	9.62	2.023	0.662	1.361	3.223	1 : 2.06

The figures in Table V, obtained by direct analysis of the insoluble deposit or "separator slime," show a striking agreement with the results obtained by the indirect method, which is brought out more clearly by expressing the above figures in the form of gram equivalents, as follows:

TABLE VI.— AMOUNTS OF ACIDS AND BASES EXPRESSED AS GRAM EQUIVALENTS.

Sample of deposit taken.	Casein as gram equivalents of acid.	Phosphates as gram equivalents of di-basic acid.	Sum of gram equivalents of casein and phosphates.	Gram equivalents of calcium.
After 1st run...............	77.7×10^{-3}	100.7×10^{-3}	**178.4×10^{-3}**	**169.3×10^{-3}**
After 6th run...............	81.1 "	82.9 "	**164.0** "	**162.3** "
After 12th run...............	80.8 "	88.1 "	**168.9** "	**167.2** "
After 18th run...............	82.8 "	87.8 "	**170.6** "	**161.2** "

The high percentage of inorganic phosphorus in the deposit from the first run indicates that the phosphates are heavier than the caseinates and could be separated from them if a certain speed were used in running the separator. This point is further shown by the following experiments: In the first experiment, the bowl of a cream separator was filled with fat-free milk (about 1,000 c.c.) and was whirled for two hours, at a speed of 5,000 revolutions per minute, when the milk was taken out and the "separator slime" which had collected on the bowl was removed and treated with alcohol and ether in the manner already described. The same milk was returned to the separator bowl and again whirled for two hours, when the deposit was again removed and treated as before. When removed the second time, that is, after four hours of whirling, the milk was nearly as clear as whey, most of the suspended phosphates and casein having

been deposited on the walls of the bowl during the whirling. The results of analysis of the "separator slime" deposited after each two hours of whirling are given in the table following:

TABLE VII.— COMPOSITION OF INSOLUBLE PORTION OF MILK DEPOSITED AT DIFFERENT INTERVALS.

"Slime" formed by whirling two 2-hour periods.	Casein.	Ash.	Total phosphorus.	Phosphorus in casein.	Phosphorus as phosphate.	Calcium.	Ratio of organic to insoluble inorganic phosphorus.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Org. P.:In. P.*
1st 2 hours.....	90.68	9.32	1.909	0.653	1.256	3.090	1 : 1.92
2nd 2 hours....	91.12	8.88	1.437	0.656	0.781	2.691	1 : 1.19

These results show that two-thirds of the insoluble inorganic phosphorus was removed during the first two hours of whirling, again indicating that the phosphates are heavier than the casein. The ratio of casein to phosphates is here also shown to be wholly irregular, indicating no definite combination.

Expressing the data in Table VII in the form of gram equivalents, we have the figures contained in the following table:

TABLE VIII.— AMOUNTS OF ACIDS AND BASES EXPRESSED AS GRAM EQUIVALENTS.

	Casein as gram equivalents of acid.	Phosphates as gram equivalents of di-basic acid.	Sum of gram equivalents of casein and phosphates.	Gram equivalents of calcium.
1st deposit....................	81.6×10^{-3}	81.1×10^{-3}	162.7×10^{-3}	154.5×10^{-3}
2nd deposit..................	82.0×10^{-3}	50.4×10^{-3}	132.4×10^{-3}	134.6×10^{-3}

An examination of these figures shows that there is the same balance between the acids (casein and phosphoric acid) and the bases (calcium and magnesium) in the two separate deposits, even when the inorganic phosphorus is as unevenly distributed between them, which furnishes proof for two points: (1st) The inorganic phosphorus must be in the form of neutral calcium phosphate ($CaHPO_4$), for otherwise the balance between bases and acids would be altered, acid calcium phosphate ($CaH_4P_2O_8$) giving an excess of acid and tri-calcium phosphate ($Ca_3P_2O_8$) an excess of base in the "slime" deposited in the first whirling. (2nd) If the phosphates were in combination with the casein, we should expect to find the ratio between the organic phosphorus and the inorganic phosphorus the same in both deposits, but, instead of uniformity, we find the ratio showing so wide a variation as 1:1.92 and 1:1.19 in the two cases.

In the second experiment, further evidence is furnished, showing that neutral calcium phosphate ($CaHPO_4$) is a normal constituent of milk. Four 500-c.c. bottles were filled with separator skim-milk to which some formaldehyde had been added, and, after standing at room temperature for 4 days, were whirled in a Bausch and Lomb precision centrifugal machine for 30 minutes at a speed of 1,200 revolutions per minute. A sediment was deposited, which after purification by treatment with alcohol and ether, as previously described, weighed 0.4 gram. Analysis of this gave the following results: Casein, 20.78 per ct.; total phosphorus, 18.38 per ct.; phosphorus combined with casein, 0.15 per ct.; phosphorus combined as phosphates, 18.23 per ct.; calcium, 22.79 per ct.; ratio of organic phosphorus to inorganic phosphorus, 1:121; casein as gram equivalents of acid, 18.7×10^{-3}; phosphates as gram equivalents of di-basic acid, $1175. \times 10^{-3}$; sum of casein and phosphates as gram equivalents of acid, $1194. \times 10^{-3}$; gram equivalents of calcium, $1140. \times 10^{-3}$.

In these figures, we again find the same balance between bases and acids, which can mean only that the phosphate compound deposited is di-calcium phosphate ($CaHPO_4$). The degree of centrifugal force developed was sufficient to throw out a relatively large amount of di-calcium phosphate but not powerful enough to throw out very much casein, thus serving as a means of effecting a nearly complete separation of these two constituents.

Babcock[5] whirled skim-milk in a separator for several hours, removing portions from time to time for analysis and finally determining the amounts of casein, calcium and phosphorus in the deposited "slime." While the experiments were preliminary in character and the results not sufficient to base permanent conclusions on, they tended to show that the casein and phosphates were not in combination. From the analytical results showing the relation of calcium to phosphorus, the conclusion was drawn that tri-calcium phosphate is the compound present in milk. The figures for calcium and phosphorus were based upon the total amounts contained in the deposit and no allowance was made for the calcium in combination with casein and the phosphorus of the casein. This fact accounts for the difference between the results presented by him and the conclusions reached by us. A recalculation of his data, after deducting the amounts of calcium and phosphorus combined with casein, gives figures that correspond to the composition of $CaHPO_4$ and not $Ca_3P_2O_8$, thus confirming the results of our work.

ACIDITY OF MILK AND MILK-SERUM.

Both fresh milk and the serum from fresh milk show a slight acid reaction to phenolphthalein. This has been believed to be due

[5] Wis. Agrl. Expt. Sta. 12th An. Rept., p. 93.

to casein or acid phosphates in the milk or to both. The fact that fresh milk and its serum are strongly alkaline to methyl orange indicates that the acidity is due to acid phosphates, though it does not necessarily show that acid caseinates are not also responsible for some of the acidity. The results of our work given in the preceding pages furnish aid in determining to what compounds in milk the acid reaction to phenolphthalein is due.

A 1,000 c.c. sample of milk was obtained from each of eight cows immediately after milking and chloroform (50 c.c.) was added to this at once. The acidity of the milk and of the milk-serum was determined after treatment with neutral potassium oxalate according to the method of Van Slyke and Bosworth.[6] The results are given below.

TABLE IX.— ACIDITY OF MILK AND MILK-SERUM.

NUMBER OF SAMPLE.	NUMBER OF C.C. OF $\frac{N}{10}$ ALKALI REQUIRED TO NEUTRALIZE 100 C.C. OF —	
	Milk.	Milk-serum.
1	4.8	5.0
2	6.2	6.2
3	4.2	4.2
4	6.0	5.8
5	6.4	6.4
6	4.4	4.4
7	7.0	6.8
8	6.6	6.4

These figures show that the acidity of fresh milk is the same as that of its serum which means that the constituents of the milk causing acidity are soluble constituents contained in the serum. Since the serum contains phosphates in amounts sufficient to furnish two to four times as much acid phosphates as is required to account for the acidity, and since, moreover, no other acid constituents of the milk-serum are present in more than minute quantities and are wholly insufficient to cause the observed degree of acidity, it appears a reasonable conclusion that the acidity of fresh milk is due to soluble acid phosphates. This conclusion is further strengthened by the results given in the preceding pages which go to show conclusively that the insoluble constituents of fresh milk are neutral in reaction, consisting largely or wholly of neutral calcium caseinate (casein Ca_4), neutral di-calcium phosphate ($CaHPO_4$) and fat.

[6] N. Y. Agrl. Expt. Sta. Tech. Bul. No. 37, p. 5.

COMPOUNDS OF MILK.

It is difficult to learn what are the individual forms or compounds in which the salts exist in milk. Attempts have been made to determine this by inferences based on analytical results. In view of the data presented in the preceding pages, taken together with many other analytical data worked out by us, we suggest the following statement as representing in some respects more closely than previous ones, facts corresponding to our present knowledge of the principal constituents of milk. The amounts are based on milk of average composition.

Fat	3.90	per ct.
Milk-sugar	4.90	"
Proteins combined with calcium	3.20	"
Di-calcium phosphate ($CaHPO_4$)	0.175	"
Calcium chloride ($CaCl_2$)	0.119	"
Mono-magnesium phosphate ($MgH_4P_2O_8$)	0.103	"
Sodium citrate ($Na_3C_6H_5O_7$)	0.222	"
Potassium citrate ($K_3C_6H_5O_7$)	0.052	"
Di-potassium phosphate (K_2HPO_4)	0.230	"
Total solids	12.901	per ct.

A CONTRIBUTION TO THE CHEMISTRY OF PHYTIN.*

SUMMARY.

R. J. ANDERSON.

This bulletin contains the report of an investigation concerning the composition of the organic phosphoric acids of cottonseed meal, oats and corn in comparison with commercial phytin.

It is shown that from all of these substances identical barium salts are obtained which agree very closely in composition with the following types of salts, viz:

Tribarium inosite hexaphosphate, $C_6H_{12}O_{24}P_6Ba_3$, obtained as minute bundles or globules of microscopic needles from dilute hydrochloric acid solutions by the addition of alcohol, and heptabarium inosite hexaphosphate $(C_6H_{11}O_{24}P_6)_2Ba_7$, or $C_{12}H_{22}O_{48}P_{12}Ba_7$ which separates from dilute hydrochloric acid solutions in the presence of barium chloride in globular masses of needle-shaped crystals.

The free acid prepared from the crystalline barium salts agrees more closely in composition with inosite hexaphosphate, $C_6H_{18}O_{24}P_6$, than with the usual formula for phytic acid, $C_6H_{24}O_{27}P_6$.

Oats apparently contains two different organic phosphoric acids but only one, that corresponding to inosite hexaphosphate, has been isolated in pure form.

The spontaneous decomposition products of phytic acid unaer ordinary conditions which are formed within a reasonable length of time appear to be phosphoric acid and substances which contain more carbon and less phosphorus than phytic acid, which substances are probably penta-, tetra-, etc., phosphoric acid esters of inosite.

When phytic acid is dried at a temperature of 105° under reduced pressure, it rapidly decomposes with liberation of inorganic phosphoric acid and the formation of various decomposition products, consisting of inosite and substances varying in composition from inosite tetraphosphate to inosite monophosphate.

When the crystalline barium salts are dried at 105° under reduced pressure they suffer but slight hydrolysis. Under ordinary conditions the dry salts are comparatively stable but on longer keeping small quantities of inorganic phosphoric acid are liberated.

* Reprint of Technical Bulletin No. 32, January.

From the analytical data reported it appears that the substance known as phytic acid or inosite phosphoric acid is either inosite hexaphosphate, $C_6H_{18}O_{24}P_6$ or else an isomer and that the formulas, $C_2H_8O_9P_2$ or $C_6H_{27}O_{18}P_6$ heretofore used to represent this acid are incorrect.

CONCERNING THE ORGANIC PHOSPHORIC ACID OF COTTONSEED MEAL. II.

In the last report[1] from this laboratory we described certain crystalline barium salts of the organic phosphoric acid of cottonseed meal. We had also prepared and analyzed the free acid itself and described its properties and we also showed that on cleavage with dilute sulphuric acid in a sealed tube the substance gave inosite as one of the products of decomposition.

These crystalline barium salts and the free acid prepared from them gave results on analysis which differed slightly from corresponding compounds calculated on the usual formula for phytic acid, viz: $C_6H_{24}O_{27}P_6$. The substance from cottonseed meal appeared to be an acid of the formula $C_2H_6O_8P_2$ or $C_6H_{18}O_{24}P_6$. The barium salts agreed closely with this formula but the percentage of phosphorus in the free acid was found to be about 1 per ct. lower than required.

The reactions of the aqueous solution of the free acid, however, were found to be identical in every respect with those given by phytic acid. From the results obtained we concluded that the organic phosphoric acid in cottonseed meal was very similar to phytic acid but we were unable to determine whether it was identical with this acid.

Prior to our publication, so far as we are aware, no definite organic phosphoric acid had ever been described as existing in cottonseed meal; no pure salts of this acid had been obtained nor had the free acid been prepared in pure form.

However, some earlier work had been published by Rather[2] dealing with "The forms of phosphorus in cottonseed meal." This author had isolated certain more or less impure substances from cottonseed meal which undoubtedly contained some of the organic phosphoric acid which we later isolated in pure form. He found that these preparations gave reactions similar to those of meta- and pyrophosphoric acids and he concluded that these reactions therefore were not sufficient to prove that either meta- or pyrophosphoric acid exists in cottonseed meal as had been claimed earlier.[3]

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[1] *Journ. Biol. Chem.* 13:311, 1912, and N. Y. Agr. Exp. Sta. Tech. Bull. 25, 1912.
[2] Texas Agr. Exp. Sta., Bull. 146.
[3] Hardin. S. C. Agr. Exp. Sta., Bull. 8, N. S., 1892.

From the acid preparations which he had isolated, he prepared some silver salts for which he proposed the following formulas, viz:

Product A, $C_4H_{12}Ag_5P_3O_{15}$.
Product B, $C_6H_{10}Ag_7P_4O_{17}$.
Product C, $C_4H_{10}Ag_5P_3O_{13}$.

In a more recent publication by the same author [4] are reported the analyses of a few more amorphous silver salts prepared, by a method similar to the one used before, from cottonseed meal and wheat bran. It is claimed that these compounds are identical, i.e., they are salts of the same acid, as shown by their having the same percentage composition, the same solubility, etc. This time, however, these amorphous compounds are alleged to be salts of an acid of the formula $C_{12}H_{41}P_9O_{42}$ and which formula is proposed as the correct one for the substance known as inosite phosphoric acid or phytic acid.

Since these results did not harmonize with our earlier findings in respect to cottonseed meal Mr. Rather suggests that the carefully purified and recrystallized barium salts which we had analyzed must have contained " iron, aluminum, lime and magnesia "— this being the more likely since we had presented no analytical data to show that these inorganic substances were absent. Evidently Mr. Rather had not read our publication very carefully, otherwise he might have noticed that we stated, concerning the barium salts, that, " metals other than barium were absent." [5]

In the present paper we wish to refer to the work on cottonseed meal only, reserving for a later communication proofs to show that the results reported by Rather are just as inapplicable to the organic phosphorus compound of wheat bran as they are to the acid existing in cottonseed meal.

Since our earlier work had shown that the organic phosphoric acid of cottonseed meal gave barium salts which crystallized readily and which could be easily purified by repeated recrystallizations and since it is generally recognized that crystalline substances are more suitable for the identification of chemical compounds than amorphous bodies we have repeated our former work on cottonseed meal in the hope of establishing more definitely the composition of the organic phosphoric acid present in this material.

From 25 pounds of cottonseed meal we obtained, after recrystallizing eleven times, 69 grams of the barium salt. So far as composition, crystal-form and reactions are concerned this product was identical with the salts previously described. Further recrystal-

[4] *J. Am. Chem. Soc.* 35:890, 1913, and Texas Agr. Exp. Sta., Bull. 156, 1913.
[5] *Loc. cit*, p. 321 and p. 11.

lizations did not alter the composition. Heavy metals other than barium were absent and we could not detect any weighable quantity of alkalies in 0.5 gram of the salt. It was completely free from inorganic phosphate and it was free from nitrogen and sulphur. We believe, therefore, that it represents a pure chemical compound.

The composition as previously reported[6] agrees very closely with that required by inosite hexaphosphate, $C_6H_{18}O_{24}P_6$. The free acid was prepared and analyzed, which also agreed with the above formula. Silver salts were prepared from the above isolated acid but it would seem that silver salts are not very suitable for the purpose of identifying an acid of the above nature. They are obtained as amorphous precipitates which do not represent homogeneous salts. They are evidently mixtures of more or less acid silver salts.

The silver precipitates which we obtained did not agree in composition with the compounds analyzed by Rather nor did they agree with any definite silver salts of inosite hexaphosphate. As suggested above, they are evidently mixtures of more or less acid silver salts of inosite hexaphosphate — for after deducting the amount of silver found, allowing for a corresponding amount of hydrogen and water and calculating to the free acid, the results agree very closely with the percentage composition calculated for inosite hexaphosphate.

In the isolation and purification of the barium salt we made use of our former method in preference to that proposed by Rather for the reason that we consider our method more simple and convenient. The essential difference in these methods of isolation is that we use barium hydroxide throughout, precipitating the substance with this reagent from dilute hydrochloric acid solutions. Rather used a modification of the method of Patten & Hart[7] — substituting the use of sodium hydroxide with ammonium hydroxide. The use of either sodium or ammonium hydroxide which must be eliminated again is not necessary, for barium hydroxide is equally efficient and by its use the introduction of other basic ions is avoided.

Since the present work substantiates our earlier results and since all the analytical data agrees with inosite hexaphosphate, $C_6H_{18}O_{24}P_6$, or with salts of this acid, we believe that the organic phosphoric acid in cottonseed meal must be represented by the formula either of inosite hexaphosphate, $C_6H_{18}O_{21}P_6$, or else some formula isomeric with this.

It may be noted that the percentage of phosphorus found on analyzing the free acid is somewhat low. In the analyses of the acids previously reported[8] the phosphorus was found to be from

[6] *Loc. cit.*
[7] *Am. Chem., Journ.* 31:566, 1904.
[8] *Loc. cit.*

1 to 1.8 per ct. lower than required for inosite hexaphosphate. As will be shown later in this bulletin, this is due to the fact that the free acid becomes largely hydrolyzed on drying.

EXPERIMENTAL PART.

ISOLATION AND PURIFICATION OF THE BARIUM SALT.

The cottonseed meal, 25 pounds, was digested over night in 0.2 per ct. hydrochloric acid in porcelain percolators covered on the inside with a double layer of cheesecloth. It was then percolated using 0.2 per ct. hydrochloric acid until about 20 liters of extract were obtained. The extract was of a dirty, dark color and contained some suspended particles from which it was freed as much as possible by centrifugalizing the solution. A concentrated solution of 300 grams of barium chloride was then added and the precipitate allowed to settle. The precipitate was centrifugalized and finally brought upon a Buchner funnel and freed as far as possible from the mother-liquor. It was then digested in several liters of about 5 per ct. hydrochloric acid until no further solution took place. The insoluble residue was removed by centrifugalizing and the still very dirty colored solution precipitated by adding barium hydroxide until the free acid was neutralized. The barium hydroxide was added slowly, with constant shaking, when the precipitate separated in crystalline form. It was then filtered and washed thoroughly in water and again dissolved in dilute hydrochloric acid, filtered and reprecipitated with barium hydroxide. These operations were repeated three times. The hydrochloric acid solution was then precipitated by gradually adding an equal volume of alcohol when the substance again separated in crystalline form consisting of globular masses of microscopic needles. It was then precipitated a fourth time with barium hydroxide and after that two more times with alcohol. It was then filtered, washed free of chlorides with dilute alcohol and then in alcohol and ether and dried in vacuum over sulphuric acid. The product was then a nearly white, crystalline powder and it weighed 94 grams.

The dry substance was shaken up with about 1.5 liters of cold water, allowed to stand for several hours and then filtered and washed in water. The aqueous solution contained very little substance precipitable with alcohol and it was therefore discarded.

The washed precipitate was dissolved in dilute hydrochloric acid and precipitated a fifth time by the very gradual addition of barium hydroxide; after filtering and washing, this operation was repeated a sixth time. After again dissolving in dilute hydrochloric acid, nearly neutralizing the free acid with barium hydroxide and filtering, the substance was brought to crystallization by the gradual addition of an equal volume of alcohol. After standing for several hours the substance was filtered and washed in dilute alcohol,

alcohol and ether and dried in vacuum over sulphuric acid. It was then a voluminous snow-white crystalline powder.

The dry substance was again dissolved in dilute hydrochloric acid, the free acid nearly neutralized with barium hydroxide and the solution filtered and allowed to stand over night. The substance soon began to crystallize. Under the microscope it appeared perfectly homogeneous and consisted as before of globular masses of microscopic needles. The substance was filtered, washed free of chlorides with water and then in alcohol and ether and dried in vacuum over sulphuric acid. The dry, snow-white, crystalline powder weighed 69 grams.

Qualitative analysis failed to reveal any heavy metals other than barium and from 0.5 gram of the salt no weighable residue of alkali was obtained. It gave no reaction with ammonium molybdate in nitric acid solution. It was free from sulphur and nitrogen.

It was analyzed after drying at 105° in vacuum over phosphorus pentoxide.

0.4641 gram subst. gave 0.0556 gram H_2O and 0.1125 gram CO_2.
0.1982 gram subst. gave 0.1333 gram $BaSO_4$ and 0.1203 gram $Mg_2P_2O_7$.

Found: C = 6.61; H = 1.34; P = 16.91; Ba = 39.57 per ct.

For tribarium inosite hexaphosphate:

$C_6H_{12}O_{24}P_6Ba_3 = 1066$.
Calculated: C = 6.75; H = 1.12; P = 17.44; Ba = 38.65 per ct.

A portion of this salt was recrystallized as follows: 5 grams were dissolved in a small quantity of 5-per-ct. hydrochloric acid and the free acid nearly neutralized with barium hydroxide, the solution was then filtered and 2 grams of barium chloride dissolved in a little water added and the solution allowed to stand. The substance separated slowly in the usual crystal form. After two days it was filtered, washed free of chlorides with water, again dissolved in the dilute hydrochloric acid, the solution filtered and alcohol added gradually until a slight cloudiness remained. After standing for 24 hours at room temperature the substance had crystallized in the usual form. It was filtered, washed free of chlorides in dilute alcohol and then in alcohol and ether, and dried in vacuum over sulphuric acid. The dilute nitric acid solution of the substance gave no reaction with ammonium molybdate. The snow-white crystalline powder was analyzed after drying at 105° in vacuum over phosphorus pentoxide.

0.3588 gram subst. gave 0.0464 gram H_2O and 0.0867 gram CO_2.
0.1726 gram subst. gave 0.1138 gram $BaSO_4$ and 0.1058 gram $Mg_2P_2O_7$.

Found: C = 6.59; H = 1.44; P = 17.08; Ba = 38.79 per ct.

Another portion of the substance was recrystallized as follows: 2 grams were dissolved in a small amount of the dilute hydrochloric acid, barium hydroxide added, with constant shaking, until a faint permanent precipitate remained, and the solution filtered. The filtrate was then heated to boiling and allowed to stand for a few minutes. As the temperature rose the solution began to turn cloudy and finally a heavy precipitate separated which appeared to be amorphous at first but it soon changed into the same crystal form as previously described. This was filtered and washed free of chlorides in boiling water and then in alcohol and ether and allowed to dry in the air. The dry substance weighed 1.6 grams. The snow-white crystalline powder was free from inorganic phosphate. It was analyzed after drying at 105° in vacuum over phosphorus pentoxide.

0.4695 gram subst. lost 0.0443 gram H_2O.
0.4252 gram subst. gave 0.0423 gram H_2O and 0.0981 gram CO_2.
0.1238 gram subst. gave 0.0885 gram $BaSO_4$ and 0.0735 gram $Mg_2P_2O_7$.

Found: $C = 6.29$; $H = 1.11$; $P = 16.54$; $Ba = 42.06$; $H_2O =$ 9.43 per ct.

For heptabarium inosite hexaphosphate $(C_6H_{11}O_{24}P_6)_2Ba_7 = 2267$.
Calculated: $C = 6.35$; $H = 0.97$; $P = 16.40$; $Ba = 42.39$ per ct.
For 14 H_2O calculated, 10.00 per ct.

Still another portion of the substance was recrystallized in the following manner: 2 grams were dissolved in the dilute hydrochloric acid and then nearly neutralized with barium hydroxide as before. The solution was filtered and 10 c.c. $^N/_1$ barium chloride added and allowed to stand over night. The substance had then separated as a heavy crystalline powder of the same form as before except that the individual crystals were much larger. The crystals were filtered, washed free of chlorides with water and finally in alcohol and ether and allowed to dry in the air. It was analyzed after drying as above.

0.6430 gram subst. lost 0.0745 gram H_2O.
0.5685 gram subst. gave 0.0603 gram H_2O and 0.1258 gram CO_2.
0.2208 gram subst. gave 0.1608 gram $BaSO_4$ and 0.1252 gram $Mg_2P_2O_7$.

Found: $C = 6.03$; $H = 1.18$; $P = 15.80$; $Ba = 42.85$; $H_2O =$ 11.58 per ct.

For heptabarium inosite hexaphosphate $(C_6H_{11}O_{24}P_6)_2Ba_7 = 2267$.

Calculated: $C = 6.35$; $H = 0.97$; $P = 16.40$; $Ba = 42.39$ per ct.
For 16 H_2O calculated: 11.27 per ct.

PREPARATION OF THE FREE ACID.

The acid was prepared in the usual way from 10 grams of the first crystalline barium salt. The aqueous solution finally obtained was concentrated in vacuum at 40° to 45° to small bulk. It was then divided into three portions — one was dried in vacuum over sulphuric acid and then analyzed — the others were used for the preparation of the silver salts to be described later.

The dry acid was obtained as a practically colorless syrup. Its dilute aqueous solution gave no reaction with ammonium molybdate showing absence of inorganic phosphoric acid. Its reactions in other respects were identical with those previously described. For analysis it was dried first in vacuum over sulphuric acid at room temperature and finally in vacuum over phosphorus pentoxide at 105°, when it turned quite dark in color.

0.3931 gram subst. gave 0.1088 gram H_2O and 0.1540 gram CO_2.
0.1840 gram subst. gave 0.1826 gram $Mg_2P_2O_7$.

Found: $C = 10.68$; $H = 3.09$; $P = 27.66$ per ct.
For inosite hexaphosphate, $C_6H_{18}O_{24}P_6 = 660$.

Calculated: $C = 10.90$; $H = 2.72$; $P = 28.18$ per ct.

PREPARATION OF THE SILVER SALT FROM THE ABOVE ACID.

One portion of the free acid previously mentioned was dissolved in 100 c.c. of water and the solution neutralized to litmus with ammonia. Silver nitrate solution was then added which caused a heavy, perfectly white, amorphous precipitate. This was filtered and carefully washed in water and dried in vacuum over sulphuric acid, desiccator being kept in a dark place. After drying, the substance was a faintly cream-colored powder which was very slightly sensitive to light. On moist litmus paper it showed a strong acid reaction. It was free from ammonia. For analysis it was dried at 105° in vacuum over phosphorus pentoxide. On drying as above, not protected from light, the substance darkened somewhat in color.

0.3064 gram subst. gave 0.0150 gram H_2O and 0.0446 gram CO_2.
0.1640 gram subst. gave 0.1387 gram AgCl and 0.0596 gram $Mg_2P_2O_7$.

Found: $C = 3.96$; $H = 0.54$; $P = 10.13$; $Ag = 63.65$ per ct.

Deducting the above percentage of silver and allowing for an equivalent amount of hydrogen and water we obtain the following results:

Calculated: $C = 10.74$; $H = 3.08$; $P = 27.45$ per ct.

These percentages agree fairly closely with the composition calculated for inosite hexaphosphate, viz:

C = 10.90; H = 2.72; P = 28.18 per ct.

To the remaining portion of the acid (about 5 c.c.) 300 c.c. of alcohol was added.* The solution remained perfectly clear. The alcohol was evaporated on the water-bath and the residue taken up in 100 c.c. of water in which it gave a slightly cloudy solution and which had a faint, aromatic odor. The acid had possibly been esterified to a slight extent. It was filtered and neutralized to litmus with ammonia and precipitated with silver nitrate; the precipitate filtered, washed in water and dried as before. The appearance of the precipitate was identical with the first one. On moist litmus paper it also showed a strong acid reaction and it was free from ammonia. For analysis it was dried as above.

0.4008 gram subst. gave 0.0176 gram H_2O and 0.0600 gram CO_2.
0.1481 gram subst. gave 0.1241 gram AgCl and 0.0548 gram $Mg_2P_2O_7$.

Found: C = 4.08; H = 0.49; P = 10.31; Ag = 63.06 per ct.

Calculated to the free acid as before the following percentages are obtained:

C = 10.88; H = 2.84; P = 27.52 per ct.

That the silver precipitates obtained under above conditions do not represent homogeneous salts may be seen by comparing the percentages found with the calculated composition of the following silver salts of inosite hexaphosphate:

$C_6H_7O_{24}P_6Ag_{11} = 1836$.
Calculated: C = 3.92; H = 0.38; P = 10.13; Ag = 64.65 per ct.
$C_6H_8O_{24}P_6Ag_{10} = 1729$.
Calculated: C = 4.16; H = 0.45; P = 10.75; Ag = 62.40 per ct.

Judging by the analytical results the amorphous silver precipitates appear to be mixtures of the above silver salts.

*NOTE: Mr. Rather found that his acid preparations gave a precipitate on addition of alcohol. This was no doubt due to the fact that inorganic bases had not been completely removed by his method of purification; hence an acid salt of the organic phosphoric acid was precipitated on the addition of alcohol. The acid prepared from our purified and recrystallized barium salts is completely soluble in alcohol.

CONCERNING PHYTIN IN OATS.

In continuation of the investigation of the organic phosphoric acids of grains and feeding materials which has been carried out in this laboratory we have examined recently the compound existing in oats. This substance has already been studied by other investigators, notably by Hart and Tottingham [1] who came to the conclusion that oats contained phytin. The purpose of the present investigation was to determine whether the phytin in oats was identical with other phytin preparations obtained from other grains.

We have previously shown that cottonseed meal [2] contains an organic phosphoric acid which differs slightly in composition from that required for the phytic acid formula of Posternak, viz: $C_2H_8O_9P_2$ or according to Neuberg $C_6H_{24}O_{27}P_6$, although so far as properties and reactions were concerned no differences could be observed. This acid from cottonseed meal had been isolated as a crystalline barium salt and since this salt did not show any change in composition on recrystallization we felt reasonably certain that it was a homogeneous substance. On the other hand we were unable to obtain any crystalline barium salts of the organic phosphoric acid of wheat bran.[3] Only amorphous salts were obtained, which differed entirely in composition from salts of phytic acid. It appeared of interest, therefore, to determine whether other grains contained organic phosphoric acids identical with those previously described or if compounds of different composition were present.

In the present investigation the substance was isolated as a barium salt from 0.2 per ct. hydrochloric acid extract of oats by precipitating with barium chloride. The substance was then repeatedly precipitated from dilute hydrochloric acid alternately with alcohol and with pure recrystallized barium hydroxide (Kahlbaum) until all bases other than barium were removed and until all the inorganic phosphate was eliminated.

Several preparations were made from different lots of oats. The substances showed absolutely no tendency to crystallize and they were all obtained as snow-white amorphous powders. On analysis these various preparations gave fairly concordant results but the composition differed considerably from that required for salts of phytic acid. The preparations were reprecipitated and subjected to various other treatments but were always recovered without showing any great variation in composition and it was therefore thought the substance was homogeneous.

However, it was found finally that these preparations, obtained by direct precipitation, were mixtures of barium salts; probably

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[1] Wis. Agr. Exp. Sta., Research Bull. 9, 1910.

[2] *Journ. Biol. Chem.* 13:311, 1912, and N. Y. Agr. Exp. Sta., Tech. Bull. 25, 1912; and preceding article.

[3] *Journ. Biol. Chem.* 12:477, 1912, and N. Y. Agr. Exp. Sta., Tech. Bull. 22, 1912.

of two different organic phosphoric acids. Only one, however, has been isolated in pure form. By treating the above mentioned amorphous barium salts with small quantities of cold water it was possible to effect a separation into two preparations having entirely different compositions. After the water-soluble portion had been removed the insoluble substance was found to crystallize readily in the same manner and in the same crystal-form as the barium salt obtained from the acid extracted from cottonseed meal, viz: in round or globular masses of microscopic needles. Repeated recrystallizations did not alter the composition except as to the percentage of barium. When allowed to crystallize from dilute hydrochloric acid containing barium chloride a salt is obtained which contains from 40 to 42 per ct. of barium; when it is brought to crystallize from dilute hydrochloric acid solutions by the addition of alcohol the salt contains about 38 per ct. of barium. So far as one can judge by crystal-form, composition, properties and reactions, the crystalline salts obtained from oats and cottonseed meal are identical.

The water-soluble substance referred to above could be obtained only as a snow-white amorphous powder. In composition it differed entirely from the crystalline product but very slightly from the compound isolated from wheat bran.[4] Owing to the amorphous nature of the substance, however, it is impossible to say at present whether it is a homogeneous body or merely a mixture of various compounds. We hope to study this matter more closely, particularly in comparison with the wheat bran products which we propose to investigate further.

The composition of the crystalline barium salts obtained from oats and cottonseed meal does not agree with the usually accepted formula for phytic acid, viz: $C_6H_{24}O_{27}P_6$. The analytical results of these preparations would indicate that they are salts of an acid of the formula $C_2H_6O_8P_2$ or a multiple of it; probably $C_6H_{18}O_{24}P_6$. Such an acid would be isomeric or identical with inosite hexaphosphate which was suggested by Suzuki and Yoshimura[5] as the formula for phytic acid. We have always found, however, that the phosphorus in the free acid prepared from the above barium salts is always about 1 per ct. lower than this formula requires. It is possible that this low percentage of phosphorus is due to partial hydrolysis in drying — which seems the more likely as the hydrogen is always found somewhat high. When the free acid is dried at a temperature of 100° or higher it turns perfectly black in color; even on drying at 60° or 78° in vacuum the color darkens perceptibly, which would indicate some decomposition. It will be shown later that hydrolysis actually does take place on drying and that a large

[4] *Loc. cit.*
[5] Coll. of Agric. Tokyo, Bull. 7:495.

percentage of the phosphorus in the dried preparations is present as inorganic phosphoric acid.

The analyses of the barium salts on the other hand agree very closely with the formula $C_2H_4O_8P_2Ba$ or $C_6H_{12}O_{24}P_6Ba_3$. It will be shown also that the barium salts suffer but very slight hydrolysis on drying at a temperature of 105°. Evidently, therefore, it is safer to calculate the formula of the free acid from the barium salts rather than from analyses of the free acid itself.

EXPERIMENTAL PART.

ISOLATION OF THE SUBSTANCE.

Whole ground oats, including grain and hull, were digested over night in 0.2 per ct. hydrochloric acid in porcelain percolators covered on the inside with a double layer of cheesecloth. The next day the substance was percolated with the same strength hydrochloric acid until the extract gave no appreciable precipitate with barium chloride. The extract was then filtered through paper and precipitated by adding a concentrated solution of barium chloride in liberal excess. The precipitate, after settling, was filtered on a Buchner funnel and washed in 30 per ct. alcohol. It was then dissolved in sufficient dilute hydrochloric acid, about 1 or 2 per ct., filtered and the filtrate precipitated with barium hydroxide solution. After settling, filtering and thoroughly washing with water the precipitate was again dissolved in the same strength hydrochloric acid as before, filtered and the filtrate precipitated by adding an equal volume of alcohol. After repeating these operations alternately a second time the substance was twice precipitated from dilute hydrochloric acid, same strength as above, with barium hydroxide (Kahlbaum) which had been recrystallized. It was then further precipitated three times from the same strength hydrochloric acid with alcohol. The final precipitate was filtered and washed free of chlorides with dilute alcohol and then in alcohol and ether and dried in vacuum over sulphuric acid.

The crude precipitate obtained by adding barium chloride to the acid extract of oats contains large quantities of impurities, inorganic phosphates, colored substances, etc., which during the above operations are gradually eliminated. The precipitates obtained at first do not dissolve completely in dilute hydrochloric acid. It is therefore necessary to filter such solutions repeatedly in order to free them from suspended insoluble matter. Finally, however, a product is obtained which is readily and completely soluble in the dilute hydrochloric acid, in which it gives a perfectly colorless solution.

When prepared as mentioned above, the dry substance is a snow-white, amorphous powder. It is very readily soluble in dilute hydrochloric and nitric acid, less so in acetic acid. It is

soluble to a considerable extent in cold water. On moist litmus paper it shows a strong acid reaction. Heated with hydrochloric acid and phloroglucine, no appreciable color reaction developed. After boiling with dilute sulphuric acid for several minutes, filtering and neutralizing, it did not reduce Fehling's solution. It contained neither nitrogen nor sulphur and gave no reaction for chlorides. Dissolved in dilute nitric acid it gave no reaction with ammonium molybdate even after being kept at a temperature of 65° for some time and standing at room temperature for several days, showing that inorganic phosphates were absent. Bases, other than barium, could not be detected in 0.5 gram of the substance.

Owing to loss in purification the yield is rather unsatisfactory. In one case 13 grams were obtained from 5 kg. of oats; in another case 20 grams were obtained from 10 kg. In all, four preparations were made, which gave a total of about 140 grams of the barium salt.

Much time was expended in an endeavor to obtain the substance in crystalline form but as already mentioned it showed no tendency whatever to crystallize. The amorphous preparations were therefore analyzed after previous drying to constant weight at 105° in vacuum over phosphorus pentoxide. The following results were obtained:

1st preparation: $C = 8.84$; $H = 1.67$; $P = 15.88$; $Ba = 36.72$ per ct.
2d preparation: $C = 8.27$; $H = 1.47$; $P = 16.28$; $Ba = 37.26$ per ct.
3d preparation: $C = 8.37$; $H = 1.60$; $P = 16.48$; $Ba = 36.79$ per ct.
4th preparation: $C = 8.44$; $H = 1.61$; $P = 16.35$; $Ba = 36.61$ per ct.

These results are fairly concordant but the composition differs considerably from that required for tribarium phytate. Calculated for $C_6H_{18}O_{27}P_6Ba_3$: $C = 6.42$; $H = 1.60$; $P = 16.60$; $Ba = 36.78$ per ct.

FURTHER PURIFICATION OF THE BARIUM SALT.

In order to determine whether the composition of the substance would change on further treatment, the following experiment was tried. A portion of the *first preparation* was used. The barium was precipitated with slight excess of sulphuric acid, the barium sulphate filtered off and the filtrate precipitated with excess of copper acetate. The copper salt was filtered and thoroughly washed in water and then suspended in water and decomposed with hydrogen sulphide. After removing the copper sulphide, the filtrate was boiled to expel hydrogen sulphide and then precipitated with a solution of recrystallized barium hydroxide. Dilute hydrochloric

acid was then added until the precipitate was just dissolved and the solution precipitated by adding an equal volume of alcohol. The precipitate was filtered, washed in dilute alcohol and then dissolved in 0.5 per ct. hydrochloric acid and reprecipitated with alcohol. The precipitate was then filtered, washed in dilute alcohol, alcohol and ether, and dried in vacuum over sulphuric acid. It was analyzed after drying at 105° in vacuum over phosphorus pentoxide.

Found: C = 8.23; H = 1.56; P = 16.19; Ba = 37.46 per ct.

In another case 6 grams of the *second preparation* were heated in a sealed tube with 45 c.c. of $^{1.5}/_{N}$ sulphuric acid in the steam-bath for twenty-four hours and then allowed to stand for four days at room temperature. After isolating in the same manner as above 3.7 grams were recovered. It was analyzed after drying as above.

Found: C = 8.42; H = 1.66; P = 16.17; Ba = 37.08 per ct.

These treatments apparently caused no change in composition.

The free acid was then prepared and analyzed. From the *first preparation*, the acid was prepared in the usual way — i. e. the barium was precipitated with slight excess of sulphuric acid, filtered, and the filtrate precipitated with copper acetate. The copper salt was filtered, washed and decomposed with hydrogen sulphide, filtered and evaporated in vacuum at a temperature of 40°–45° and finally dried in vacuum over sulphuric acid. It was thus obtained as a thick, practically colorless syrup. For analysis it was dried to constant weight over boiling chloroform in vacuum over phosphorus pentoxide. The color turned very slightly dark on drying in this way.

Found: C = 13.24; H = 3.26; P = 25.50 per ct.

The acid prepared from the repurified barium salt gave the following result on analysis after drying as above.

Found: C = 13.17; H = 3.39; P = 25.48 per ct.

The composition of the acid agrees with that required for the above barium salts and one might suppose from the close agreement of analytical results that the substance was homogeneous.

It was found, however, that after the barium salt had been precipitated a great number of times from dilute hydrochloric acid by barium hydroxide and alcohol alternately that the composition did change slightly. The same result was also observed on digesting the barium salt in dilute acetic acid. After treating in the above manner, barium salts of the following composition were obtained:

I: C = 7.49; H = 1.63; P = 16.77; Ba = 37.89 per ct.
II: C = 7.69; H = 1.47; P = 16.75; Ba = 37.72 per ct.
III: C = 7.26; H = 1.75; P = 16.45; Ba = 36.40 per ct.

These salts were united and dissolved in the least possible amount of 0.5 per ct. hydrochloric acid and alcohol added to the solution until a faint permanent turbidity remained — which was just cleared up by the addition of a few drops of dilute hydrochloric acid. The solution was then allowed to stand at room temperature for about two days. There separated slowly a heavy white crust on the bottom of the flask. Under the microscope this showed no definite crystalline structure. The substance was filtered off, washed thoroughly in water, alcohol and ether and dried in the air. It was free from chlorides and gave no reaction with ammonium molybdate. For analysis it was dried at 105° in vacuum over phosphorus pentoxide.

Found: C = 6.07; H = 1.35; P = 16.77; Ba = 40.00; H_2O = 10.08 per ct.

The carbon found is undoubtedly somewhat too low, as this heavy compact substance burned with extreme difficulty.

The filtrate from the above was precipitated with alcohol, the precipitate filtered, washed and dried in vacuum over sulphuric acid. The following result was obtained on analysis:

Found: C = 7.63; H = 1.57; P = 16.53; Ba = 36.92 per ct.

The heavy crust-like substance was recrystallized as follows: It was dissolved in dilute hydrochloric acid, filtered and about an equal volume of alcohol added and the mixture allowed to stand over night. The precipitate which was amorphous at first had then changed into a crystalline form. Under the microscope it appeared as very small globules consisting of microscopic needles. It was filtered, washed free of chlorides in dilute alcohol, alcohol and ether and dried in vacuum over sulphuric acid. It was a light, voluminous, snow-white crystalline powder. It was analyzed after drying at 105° in vacuum over phosphorus pentoxide.

Found: C = 6.60; H = 1.50; P = 17.33; Ba = 37.45; H_2O = 8.72 per ct.

The amorphous preparations which remained were united (total weight 52.5 grams). The substance was rubbed up in a mortar with a small quantity of cold water. A considerable portion of the substance dissolved. The insoluble portion was perfectly white and opaque but it soon changed into a semicrystalline form and appeared translucent. After standing for some time it was filtered and washed in water and finally in alcohol and ether and dried in vacuum over sulphuric acid. When dry it was again treated with water in the same way. These operations were repeated three times.

The filtrates and washings from the above were precipitated by the addition of alcohol and these precipitates reserved for examination as will be described later.

The water-insoluble substance was dissolved in the least possible quantity of dilute hydrochloric acid (about 5 per ct. strength), the

free acid was then nearly neutralized with barium hydroxide; the solution filtered and alcohol added until a faint, permanent turbidity remained. A concentrated solution of 20 grams of barium chloride was then added and the whole allowed to stand. The substance soon began to crystallize in the same crystal form as the barium salt from cottonseed meal, viz: in globular masses or bundles of fine microscopic needles. After standing over night the crystals were filtered, washed free of chlorides with water and then in alcohol and ether and allowed to dry in the air. A further crop of the same-shaped crystals was obtained from the mother-liquor by carefully adding alcohol and allowing to stand. After filtering, washing and drying these were added to the first crop.

The substance was recrystallized three times in the same way. It was finally obtained as a light, snow-white crystalline powder. It weighed about 27 grams.

This was analyzed after drying at 105° in vacuum over phosphorus pentoxide.

0.2483 gram subst. lost 0.0308 gram H_2O.

0.2175 gram subst. gave 0.0295 gram H_2O and 0.0507 gram CO_2.

0.1456 gram subst. gave 0.0987 gram $BaSO_4$ and 0.0864 gram $Mg_2P_2O_7$.

Found: $C = 6.35$; $H = 1.51$; $P = 16.54$; $Ba = 39.89$; $H_2O = 12.40$ per ct.

It was again recrystallized in the same manner and the following result obtained on analysis after drying as before:

Found: $C = 6.23$; $H = 1.27$; $P = 16.17$; $Ba = 41.48$; $H_2O = 12.99$ per ct.

The substance was again dissolved in dilute hydrochloric acid, the solution was filtered and then precipitated by the addition of alcohol. The precipitate was amorphous at first but on standing in the mother-liquor over night, it had changed into the usual crystal-form but the globules and crystals were much smaller. After filtering and washing free of chlorides in dilute alcohol, alcohol and ether the substance was dried in vacuum over sulphuric acid. It was analyzed after drying at 105° in vacuum over phosphorus pentoxide.

0.2320 gram subst. gave 0.0325 gram H_2O and 0.0553 gram CO_2.

0.1466 gram subst. gave 0.0947 gram $BaSO_4$ and 0.0894 gram $Mg_2P_2O_7$.

Found: $C = 6.50$; $H = 1.56$; $P = 17.00$; $Ba = 38.01$ per ct.

As will be noticed from the above analytical results the composition does not change on repeated recrystallizations. We believe therefore that the substance is homogeneous. The variation in the percentage of barium evidently depends upon the formation of more

or less acid salts. All the preparations described showed a strong acid reaction on moist litmus paper which indicates free hydrogen ions.

In the estimation of carbon and hydrogen it was found impossible to obtain a white ash by direct combustion even when heated for a long time — the residue in the boat was invariably dark colored, varying from light gray to quite dark. Plimmer and Page [6] also mention the difficulty of completely burning carbon in the presence of phosphoric acid. The crystalline barium salts described in this paper as well as those from cottonseed meal are particularly hard to burn; on the other hand the amorphous salts burn more easily. In the combustions of these salts we have always burned the substance twice; first in the regular manner; the dark-colored ash has then been powdered in an agate mortar and mixed in the boat with chromic acid and burned a second time. In this second combustion there has been observed an increase in weight in the carbon dioxide varying from about 1 to 12 milligrams. Under these conditions it is impossible to say whether a complete combustion has been affected and it is not improbable that a small quantity of carbon has escaped oxidation. We are inclined to believe that the percentage of carbon as found is slightly low. As a check upon the carbon content found in the barium salts we have always prepared and analyzed the free acid in the combustion of which we have never experienced any serious difficulty, the residue in the boat showing no trace of carbon.

PREPARATION OF THE FREE ACID FROM THE PURIFIED CRYSTALLINE BARIUM SALT.

The acid was prepared from 4 grams of the barium salt in the usual way. After drying in vacuum over sulphuric acid at room temperature it formed a practically colorless, thick syrup. Its reactions were identical with those which we reported for the acid from cottonseed meal.[7] For analysis it was dried in vacuum over phosphorus pentoxide at 78°. The preparation darkened perceptibly in color but did not turn black.

0.4936 gram subst. gave 0.1366 gram H_2O and 0.1960 gram CO_2.
0.1645 gram subst. gave 0.1601 gram $Mg_2P_2O_7$.
Found: C = 10.82; H = 3.09; P = 27.12 per ct.

PREPARATION OF INOSITE FROM THE BARIUM SALT.

The amorphous barium salt was used. Of the dry salt, 9.3 grams were heated in a sealed tube with 25 c.c. $^5/_N$ sulphuric acid to 150°–160° for three hours. After cooling, the contents of the tube were

[6] *Biochem. Journ.* 7:167, 1913.
[7] *Loc. cit.*

very dark in color and some carbonaceous substance had separated showing that considerable decomposition had taken place. The sulphuric and phosphoric acids were precipitated with excess of barium hydroxide, filtered and washed and the filtrate freed from excess of barium with carbon dioxide. The filtrate was evaporated to small bulk and decolorized with animal charcoal and then evaporated to dryness on the water-bath. The residue was taken up in a little hot water, filtered from traces of barium carbonate and the inosite brought to crystallize by the addition of alcohol and ether. It separated in needles free from water of crystallization. After filtering, washing in alcohol and ether and drying in the air it weighed 1.6 grams which represents a yield of about 75 per ct. of the total carbon. For analysis it was recrystallized seven times in the same manner as above and was finally obtained in beautiful colorless needles free from water of crystallization. It melted at 223° (uncorrected) and gave the reaction of Scherer. It did not lose in weight on drying at 105° in vacuum over phosphorus pentoxide.

0.1442 gram subst. gave 0.0878 gram H_2O and 0.2113 gram CO_2.
Found: $C = 39.96$; $H = 6.81$ per ct.
For $C_6H_{12}O_6$ calculated: $C = 40.00$; $H = 6.66$ per ct.

HYDROLYSIS OF THE ACID WITH WATER ALONE.

The acid which was used had been prepared from the amorphous barium salt. Two grams of the dry preparation were heated with 25 c.c. of water in a sealed tube to 190° for $3\frac{1}{2}$ hours. After cooling there was no pressure on opening the tube. The content was of dark brown color and a considerable quantity of a black, carbonized substance had separated. The whole was diluted with water and filtered and the phosphoric acid was precipitated with barium hydroxide in excess. The precipitate was filtered off and examined to see if any unchanged barium phytate could be isolated from it. Apparently the acid had been completely decomposed during the heating as no trace of barium phytate could be found.

The filtrate from the barium phosphate was freed from excess of barium by carbon dioxide and the filtrate evaporated to dryness on the water-bath. The residue was a sticky, amber-colored syrup. It was taken up in a small amount of water and washed into an Erlenmeyer flask. On the addition of alcohol the solution turned cloudy but it could not be brought to crystallize by repeated scratching with a glass rod. It was allowed to stand over night when an amber-colored syrupy layer had separated on the bottom. The upper portion of the liquid was poured off and mixed with ether. On standing a further quantity of amber-colored syrup had separated. The liquid was decanted and evaporated on the water-bath until a small syrupy residue remained. On scratching with a glass rod a substance began to crystallize in small prisms. The other syrups

were made to crystallize in the same manner. They were then extracted several times with small quantities of alcohol. The residues were then dissolved in hot water and crystallized by the addition of alcohol. After recrystallizing three times it was obtained in small colorless needles. It weighed 0.25 grams. It melted at 222° (uncorrected) and gave the Scherer reaction and was therefore undoubtedly inosite. After recrystallizing it again melted at 222°. The crystals did not contain water of crystallization as there was no loss in weight on drying at 105° in vacuum for one hour. The substance was further identified as inosite by the analysis.

0.1019 gram subst. gave 0.0629 gram H_2O and 0.1492 gram CO_2.
Found: $C = 39.93$; $H = 6.90$ per ct.
For $C_6H_{12}O_6$, calculated: $C = 40.00$; $H = 6.66$ per ct.

The alcoholic washings from above and the mother-liquor on evaporation left a dark colored, non-crystallizable syrup. This syrup strongly reduced Fehling's solution on boiling.

It is noteworthy that the amount of inosite obtained by cleavage with water is much less than when dilute sulphuric acid is used. The amount of inosite isolated above represents only about one-half the quantity obtained when the hydrolysis is effected in the presence of acid. It is possible, however, that in this case the inosite had been less completely isolated since the adhering syrupy substance rendered crystallization more difficult.

EXAMINATION OF THE WATER-SOLUBLE PORTION OF THE AMORPHOUS BARIUM SALT.

As has been already mentioned on page 17 the filtrates containing the water-soluble portion of the amorphous barium salt were precipitated with alcohol. After filtering and washing, the precipitate was dried in vacuum over sulphuric acid. It was again digested in water three times and filtered from small insoluble matter and the filtrates precipitated with alcohol and dried. It was finally obtained as a snow-white amorphous powder. As it was impossible to obtain any crystalline substance from it, it was analyzed after drying at 105° in vacuum over phosphorus pentoxide.

0.3504 gram subst. lost 0.0294 gram H_2O on drying.
0.3210 gram subst. gave 0.0616 gram H_2O and 0.1342 gram CO_2.
0.2415 gram subst. gave 0.1465 gram $BaSO_4$ and 0.1236 gram $Mg_2P_2O_7$.

Found: $C = 11.40$; $H = 2.14$; $P = 14.26$; $Ba = 35.69$; $H_2O = 8.39$ per ct.

The substance was free from inorganic phosphate and chlorides, and bases other than barium could not be detected. We hope to investigate this substance further.

CONCERNING PHYTIN IN CORN.

The organic phosphoric acid compound occurring in corn has been particularly studied by Vorbrodt.[1] In an exhaustive treatise on the subject he reports analytical results obtained from crystalline barium salts which led him to believe that the substance was different from phytin. The barium salt corresponded to the formula $C_{12}H_{26}O_{46}P_{11}Ba_7$ according to which the formula of the acid would be $C_{12}H_{40}O_{46}P_{11}$. Vorbrodt also showed that the substance gave inosite and phosphoric acid on cleavage either with dilute sulphuric acid or water alone in neutral solution.

The same subject has also been investigated by Hart and Tottingham.[2] They report the preparation and analysis of the free acid. The analytical data agrees very closely with that required for phytic acid and they concluded that corn contains phytin. They also showed that the acid yields inosite on hydrolysis in a sealed tube in the presence of dilute sulphuric acid.

We have undertaken to reexamine this substance in the hope of identifying it either with phytic acid or the compounds which we have shown to exist in cottonseed meal[3] and oats.[4]

At first we were unable to obtain the barium salt in crystalline form but the amorphous salt gave results on analysis which approximately agreed with the corresponding barium phytate. The free acid, prepared from this amorphous compound, gave about one per ct. too high carbon and about 0.8 per ct. too high phosphorus.

We finally succeeded, however, in preparing a crystalline barium salt. It was purified by repeated recrystallizations until the composition remained constant. The product was free from inorganic phosphate and it did not contain a determinable quantity of bases other than barium. Judging by crystal-form, composition and properties the substance is identical with those previously isolated from cottonseed meal [5] and oats.[6]

The analytical results obtained from these purified crystalline barium salts do not agree with the formula proposed by Vorbrodt.[7] We find the phosphorus over 1 per ct. higher and the relation between carbon and phosphorus is as 1:1. The phosphorus content is also considerably higher than that required for a corresponding salt calculated on the usual phytic acid formula.

The barium salt analyzed by Vorbrodt had been prepared from the previously isolated acid by partially neutralizing with barium

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[1] Anzeiger Akad. Wiss. Krakau, 1910, Series A, p. 484.
[2] Wis. Agr. Exp. Sta., Research Bull. 9, 1910.
[3] *Journ. Biol. Chem.* 13:311, 1912, and N.Y. Agr. Exp. Sta., Tech. Bull. 25, 1912.
[4] See preceding article.
[5] *Loc. cit.*
[6] *Loc. cit.*
[7] *Loc. cit.*

hydroxide and concentrating in vacuum. The crystalline salt which then separated was washed, dried and analyzed. Apparently no attempt had been made to recrystallize it and it is probable that the substance had contained small quantities of impurities which might be sufficient to account for the difference in analytical results between his product and the repeatedly recrystallized salts which we have analyzed.

The composition of the purified salts described in this paper agrees more closely with salts of inosite hexaphosphate than with salts calculated on the basis of the usual phytic acid formula.

EXPERIMENTAL PART.

ISOLATION OF THE SUBSTANCE FROM CORN.

The corn used in these experiments was the ordinary corn meal used as cattle feed at this station. Ground corn meal, 3500 grams, was digested in 7 liters of 0.2 per ct. hydrochloric acid over night. It was then strained and filtered and the clear amber-colored filtrate precipitated by adding about $1\frac{1}{2}$ volumes of alcohol. After settling, the precipitate was filtered and washed in dilute alcohol. The precipitate was then dissolved in a small amount of 0.5 per ct. hydrochloric acid and filtered from insoluble matter. This acid solution gave only a very slight precipitate on the addition of alcohol. The substance was therefore transformed into a barium salt by precipitating with barium hydroxide to slight alkaline reaction. After heating on the water-bath for some time the precipitate was filtered and washed in water. It was again dissolved in 0.5 per ct. hydrochloric acid, filtered and reprecipitated with barium hydroxide. After standing over night the precipitate was filtered and washed thoroughly in water. The substance was again dissolved in 0.5 per ct. hydrochloric acid, filtered and then precipitated by the addition of an equal volume of alcohol. The precipitate after settling was filtered and washed in dilute alcohol. The substance was then precipitated three times more in the same manner and after finally filtering, washing in dilute alcohol, alcohol and ether, it was dried in vacuum over sulphuric acid. A white amorphous powder was obtained which weighed 11.8 grams. The substance gave no reaction for chlorides. The dilute nitric acid solution gave no reaction with ammonium molybdate after warming for some time.

The following results were obtained on analysis after drying at 105° in vacuum over phosphorus pentoxide to constant weight.

Found: C = 7.25; H = 1.51; P = 16.65; Ba = 37.11 per ct.

The carbon is somewhat high, otherwise the result agrees with the calculated percentages for tribarium phytate, $C_6H_{18}O_{27}P_6Ba_3$.

Calculated: C = 6.42; H = 1.60; P = 16.60; Ba = 36.78 per ct.

PREPARATION OF THE FREE ACID FROM THE ABOVE AMORPHOUS BARIUM SALT.

The acid was prepared from 3 grams of the barium salt in the usual way, i. e. the barium was precipitated with slight excess of sulphuric acid, filtered and the filtrate precipitated with copper acetate. The copper precipitate was filtered and washed thoroughly in water, suspended in water and decomposed with hydrogen sulphide, filtered and the filtrate evaporated in vacuum at a temperature of 40° to 45° to a syrupy consistency and finally dried in vacuum over sulphuric acid. The product was a thick, faintly amber-colored syrup. For analysis it was dried at 105° in vacuum over phosphorus pentoxide. It turned very dark in color.

Found: C = 11.09; H = 3.04; P = 26.85 per ct.

Both carbon and phosphorus are higher than required for phytic acid, $C_6H_{24}O_{27}P_6$.

Calculated: C = 10.08; H = 3.36; P = 26.05 per ct.

PREPARATION OF THE SUBSTANCE FROM CORN AS A CRYSTALLINE BARIUM SALT.

A larger quantity of corn meal was extracted with 0.2 per ct. hydrochloric acid, the extract filtered and precipitated by adding a concentrated solution of barium chloride. The precipitate was then purified and crystallized in the manner described for cottonseed meal in the preceding article. After the substance had been separated from dilute hydrochloric acid solutions twelve times (eleven times in crystalline form) it was obtained as a beautiful snow-white, bulky crystalline powder which weighed 49 grams. The crystal form was identical with that of the barium salts from cottonseed meal and oats, i. e. globular masses of microscopic needles. The substance was free from chlorides and inorganic phosphate and we were unable to detect any metals other than barium.

For analysis it was dried at 105° in vacuum over phosphorus pentoxide.

0.4101 gram subst. gave 0.0607 gram H_2O and 0.0985 gram CO_2.
0.1477 gram subst. gave 0.1035 gram $BaSO_4$ and 0.0860 gram $Mg_2P_2O_7$.
Found: C = 6.55; H = 1.65; P = 16.23; Ba = 41.23 per ct.

A portion of this salt was recrystallized as follows: 5 grams were dissolved in a small quantity of 3 per ct. hydrochloric acid; barium hydroxide was carefully added until a slight permanent precipitate remained; the solution was filtered and a concentrated solution of 2 grams barium chloride added. The perfectly clear solution was allowed to stand at room temperature for about 2 days when the

substance separated slowly in the usual form. It was filtered, washed free of chlorides with water and then in alcohol and ether and dried in the air; yield 4.5 grams. The substance gave no reaction with ammonium molybdate.

It was analyzed after drying at 105° in vacuum over phosphorus pentoxide.

0.4770 gram subst. lost 0.0561 gram H_2O.
0.1767 gram subst. lost 0.0209 gram H_2O.
0.4209 gram subst. gave 0.0491 gram H_2O and 0.0931 gram CO_2.
0.3616 gram subst. gave 0.0427 gram H_2O and 0.0832 gram CO_2.
0.1553 gram subst. gave 0.1110 gram $BaSO_4$ and 0.0907 gram $Mg_2P_2O_7$.

Found: I. C = 6.03; H = 1.30; P = 16.28; Ba = 42.06 per ct.
II. C = 6.27; H = 1.32;
H_2O = 11.76 and 11.82 per ct.

For heptabarium inosite hexaphosphate $(C_6H_{11}O_{24}P_6)_2Ba_7 = 2267$.

Calculated: C = 6.35; H = 0.97; P = 16.40; Ba = 42.39 per ct
For 16 H_2O calculated: 11.27 per ct.

This recrystallized salt was again recrystallized as follows: it was dissolved in a small quantity of 3 per ct. hydrochloric acid, filtered and diluted with a small quantity of water. Alcohol was then added until a faint permanent cloudiness remained. On standing at room temperature the substance soon began to crystallize in the usual form except that the crystals were much smaller. After standing over night it was filtered, washed in dilute alcohol, alcohol and ether and dried in vacuum over sulphuric acid. The product was a snow-white, fine crystalline powder. It gave no reaction for chlorides and none for inorganic phosphate. It was analyzed after drying at 105° in vacuum over phosphorus pentoxide.

0.3719 gram subst. gave 0.0465 gram H_2O and 0.0887 gram CO_2.
0.1780 gram subst. gave 0.1187 gram $BaSO_4$ and 0.1091 gram $Mg_2P_2O_7$.
Found: C = 6.50; H = 1.40; P = 17.08; Ba = 39.14 per ct.

For tribarium inosite hexaphosphate, $C_6H_{12}O_{24}P_6Ba_3 = 1066$.

Calculated: C = 6.75; H = 1.12; P = 17.44; Ba = 38.65 per ct.

PREPARATION OF THE FREE ACID.

The acid was prepared in the usual way from about 4 grams of the crystalline barium salt. After drying in vacuum over sulphuric acid it was obtained as a thick, very faintly amber-colored syrup. In appearance and reactions it corresponded exactly with the acids

prepared from the crystalline barium salts which have been described previously.

A portion of the above dried acid dissolved in water and acidified with nitric acid gave no precipitate after warming for some time with ammonium molybdate solution.

For analysis the preparation was dried first for ten days in vacuum over sulphuric acid at room temperature and then at 78° in vacuum over phosphorus pentoxide to constant weight. The color did not change by drying in vacuum at room temperature but at 78° the color darkened somewhat.

0.3405 gram subst. gave 0.0919 gram H_2O and 0.1356 gram CO_2.
0.1796 gram subst. gave 0.1754 gram $Mg_2P_2O_7$.
Found: C = 10.86; H = 3.02; P = 27.22 per ct.
For inosite hexaphosphate, $C_6H_{18}O_{24}P_6 = 660$.
Calculated: C = 10.90; H = 2.72; P = 28.18 per ct.
For phytic acid, $C_6H_{24}O_{27}P_6 = 714$.
Calculated: C = 10.08; H = 3.36; P = 26.05 per ct.

CONCERNING THE COMPOSITION OF BARIUM PHYTATE AND PHYTIC ACID FROM COMMERCIAL PHYTIN AND A STUDY OF THE PROPERTIES OF PHYTIC ACID AND ITS DECOMPOSITION PRODUCTS.

In previous reports from this laboratory it has been shown that the organic phosphoric acids existing in cottonseed meal,[1] oats[2] and corn[3] yield identical crystalline barium salts which differ in composition from the corresponding, so-called, barium phytates. The free organic phosphoric acids, isolated from these crystalline barium salts, although identical so far as analyses are concerned, differ in composition from phytic acid. These crystalline salts had all been carefully purified by repeated recrystallizations and it appears, therefore, reasonable to believe that they were purer than any previously described barium phytate. In so far as one may judge by crystal form, composition and reactions the above compounds are identical and are salts of an acid of the formula, $C_2H_6O_8P_2$ or $C_6H_{18}O_{24}P_6$. If the latter be the correct formula, which appears probable, then it differs from the phytic acid formula of Neuberg,[4] $C_6H_{24}O_{27}P_6$, by three molecules of water, which is also the difference between phytic acid and inosite hexaphosphate.

Previously we have reported[5] numerous salts of phytic acid prepared from commercial phytin. These salts, however, were mostly amorphous and particularly the barium salts, with one exception, were not obtained in crystalline form. These amorphous compounds gave results on analyses which corresponded closely with percentages calculated on the basis of the usual formula for phytic acid, viz: $C_6H_{24}O_{27}P_6$. In dealing with amorphous substances, however, some doubt may be felt as to their being homogeneous products.

Since the crystalline salts mentioned above differ in composition from compounds calculated on the usual formula for phytic acid we are forced to the conclusion, either that the organic phosphoric acid existing in cottonseed meal, oats and corn is different and distinct from phytic acid or else that the formula of phytic acid itself is wrong, having possibly been based upon analytical data of somewhat impure preparations.

It seemed of importance to determine whether any real difference exists between the barium salts of phytic acid prepared from commercial phytin and the crystalline salts obtained from cottonseed

[1] *Journ. Biol. Chem.* 13:311, 1912, and N.Y. Agr. Exp. Sta., Tech. Bull. 25, 1912, and also preceding article.

[2] See preceding article.

[3] See preceding article.

[4] *Biochem. Zeitschr.* 9:551, 557, 1908.

[5] *Jour. Biol. Chem.* 11:471, 1912, and 12:97, 1912, and N.Y. Agr. Exp. Sta., Tech. Bull. 19 and 21, 1912.

meal, oats and corn. We have, therefore, re-examined the commercial phytin using some of the same preparation as before.

After carefully purifying the barium salt of the substance we found that it crystallized very readily and no difference could be observed either in crystal form, composition or reactions, of the salts prepared in this way, from the crystalline salts previously referred to. All of these compounds are therefore identical and the analytical data indicate that they are salts of the acid $C_2H_6O_8P_2$ or $C_6H_{18}O_{24}P_6$.

The composition, as determined by analysis, of the free acid prepared from the crystalline barium phytate also agrees more closely with the above formulas than with the usual formula of phytic acid, $C_6H_{24}O_{27}P_6$. The phosphorus was found too low in this case as well as in the acids previously described. This, however, is undoubtedly due to the fact that the acid is largely hydrolyzed on drying.

It appears very probable then that the organic phosphoric acid described above and known as phytic acid is either inosite hexaphosphate, $C_6H_{18}O_{24}P_6$, or else an isomer of the same. We have, however, no direct information concerning the molecular magnitude of the acid.

We have endeavored to prepare a neutral ester of the acid with which molecular weight determinations might be made, but so far these attempts have failed. By acting on the silver salt of the acid, suspended in absolute methyl alcohol, with methyl iodide, an ester is formed but it apparently suffers partial decomposition in drying. Moreover we have been unable to prepare a neutral silver salt. Only acid silver salts have been obtained even from solutions of phytic acid neutralized with ammonia. From such salts, naturally, only acid esters could be obtained.

As has been pointed out by Starkenstein,[6] which observation we have confirmed,[7] apparently only one-half of the acid hydroxyls of phytic acid are particularly reactive. Some of the acid hydroxyls appear to be very weak. It is no doubt due to this fact that from a neutral solution of ammonium phytate only acid silver salts are precipitated with silver nitrate.

Starkenstein [8] reported that the commercial phytin which he had examined contained relatively large quantities of inorganic phosphate and that it also contained free inosite and he concluded that the substance undergoes spontaneous decomposition. He also found that after drying the preparation at 100° the greater portion of the phosphorus was present as inorganic phosphate.

These results, so far as the formation of inosite on mere drying is concerned, we could not confirm [9] in the phytin preparations

[6] *Biochem. Zeitschr.* 30:65, 1910.
[7] *Journ. Biol. Chem.* 11:475, 1912, and N.Y. Agr. Exp. Sta. Tech. Bull. 19, 1912.
[8] *Loc. cit.*, pp. 59 and 60.
[9] *Journ. Biol. Chem.* 11:473, 1912, and N.Y. Agr. Exp. Sta. Tech. Bull. 19, 1912.

which we had on hand. From a sample of commercial phytin which had been in our laboratory for several years we could not isolate a trace of inosite either before or after drying at 115°. At that time we made no effort to determine the increase in inorganic phosphate on drying at 100° or higher.

Observations made since then, however, have shown without any doubt that phytin undergoes spontaneous decomposition when kept under ordinary conditions at room temperature. Both the salts and the free acid decompose slowly, with liberation of inorganic phosphate. The free acid decomposes much faster than the salts. We have also found that a very perceptible increase in inorganic phosphate occurs on drying at 105° in vacuum. In this case also the free acid decomposes to a greater extent than the salts.

Although notable quantities of inorganic phosphoric acid are liberated from phytic acid and its salts under the above conditions, we have again been unable to demonstrate the presence of inosite as one of the spontaneous decomposition products. In this connection we especially examined a specimen of phytic acid which had been kept in the laboratory for about 18 months. The preparation had been kept in a glass-stoppered bottle at ordinary temperature but at no time had it been exposed to direct sunlight. When first prepared the acid was a practically colorless, thick syrup containing about 20 per ct. of water and it gave no reaction with ammonium molybdate. It darkened gradually in color and when examined the color was quite black. Analysis showed that about one-eighth of the total phosphorus was present in the form of inorganic phosphoric acid. A quantity of this preparation corresponding to 10 grams of the dry acid was examined for inosite but no trace of this substance could be found although the preparation should have contained about 0.3 gram of inosite had the organic radical corresponding to the free inorganic phosphoric acid present separated in the form of inosite.

Since the organic part of the phytic acid radical had not separated as inosite under the above conditions of spontaneous decomposition it appeared of interest to determine, if possible, what product or products had been formed and in what manner the decomposition had occurred. While we are unable to answer these questions fully at this time, the results would indicate that, under the above conditions, the phytic acid undergoes only partial decomposition with formation of penta- or tetra-phosphoric acid esters of inosite and free phosphoric acid.

The aqueous solution of the above partially decomposed phytic acid was precipitated with barium hydroxide. The barium precipitate was freed from inorganic phosphate in our usual way, i. e. by precipitating its dilute hydrochloric acid solution with alcohol until the product gave no reaction with the ammonium molybdate

reagent. The final product was a white, amorphous powder. We succeeded in separating this substance into two portions, one a crystalline salt showing all the characteristics and composition of unchanged barium phytate and a second amorphous portion which, judging by analysis, was probably a mixture of the barium salts of inosite penta- and tetra-phosphate.

Since no inosite could be isolated from this preparation, although it had been standing for 18 months and had undergone considerable decomposition, it would seem that a very long time would be required for complete decomposition, i. e., until free inosite were present. On drying a sample of the same acid at 105° for 48 hours under diminished pressure, however, the decomposition products isolated were found to be quite different. In this case we found that about 75 per ct. of the phosphorus was present as inorganic phosphoric acid and we were unable to isolate any unchanged barium phytate. Apparently all of the phytic acid had been partially decomposed and some of it completely, for we obtained 0.25 gram of inosite from 10 grams of the acid after drying as above. The organic phosphoric acid or acids remaining undecomposed were isolated as barium salts. None of these, however, could be obtained in pure form. But by taking advantage of their varying solubilities in water and mixtures of acidulated water and alcohol we were able to separate it into four fractions. All of these fractions had different composition and it would appear probable that they represent more or less impure mixtures of the barium salts, of tetra-, tri-, di-, and mono-phosphoric acid esters of inosite.

When phytic acid has been completely dried at temperatures ranging from 60° to 105° we have noticed that it is not completely soluble in water. Some insoluble substance separates in thin gelatinous plates. We have not been able to obtain a sufficient quantity of this substance for a complete examination. Judging by the analysis of one small sample it is a complex decomposition product of phytic acid, possibly a partially dehydrated tri-phosphoric acid ester of inosite.

EXPERIMENTAL PART.

PREPARATION OF THE CRYSTALLIZED BARIUM PHYTATE.

A sample of the same commercial phytin as formerly examined was transformed into the barium salt as follows: 50 grams of the substance were suspended in about 1500 cubic centimeters of water and dissolved by the careful addition of dilute hydrochloric acid. Barium hydroxide was then added to slight alkaline reaction and the whole allowed to stand over night. The barium hydroxide used was Kahlbaum C. P. which had been recrystallized. The precipitate

was filtered and washed thoroughly in water. It was dissolved in the minimum quantity of about 3 per ct. hydrochloric acid, filtered and again precipitated with barium hydroxide. These operations were repeated four times. The substance was then precipitated from the same strength hydrochloric acid with alcohol. After thoroughly washing the precipitate with dilute alcohol it was again dissolved in 3 per ct. hydrochloric acid and precipitated a fifth time with barium hydroxide. The dilute hydrochloric acid solution of the substance was then twice precipitated with alcohol. After finally filtering, the precipitate was washed free of chlorides with dilute alcohol and then washed in alcohol and ether and dried in vacuum over sulphuric acid. The substance was then a snow-white amorphous powder. The dry powder was rubbed up in a mortar with a small quantity of cold water. The insoluble portion changed into a semi-crystalline form after a short time. This was filtered and washed thoroughly in water. It was dissolved in the minimum quantity of 3 per ct. hydrochloric acid. A dilute solution of barium hydroxide was then added until a slight permanent precipitate remained which was nearly cleared up by the careful addition of dilute hydrochloric acid. The solution was filtered and allowed to stand over night. The substance soon began to separate in crystalline form. Under the microscope it appeared perfectly homogeneous and the crystal form was identical with that observed with the barium salts from cottonseed meal, oats and corn, i. e. the substance crystallized in globular masses of microscopic needles.

The substance was filtered off and washed free of chlorides with water and then in alcohol and ether and dried in vacuum over sulphuric acid.

To the mother-liquor a concentrated solution of 15 grams of barium chloride was added and allowed to stand for another 24 hours. A further quantity of the same-shaped crystals had then separated which were filtered, washed and dried as above.

The two crystalline portions were united and recrystallized in the same manner and again dried in vacuum over sulphuric acid. It was then dissolved in the same strength hydrochloric acid and precipitated by adding an equal volume of alcohol. The precipitate was amorphous at first but after standing a few hours it had changed into the crystalline form — identical with the above but the crystals were much smaller. After standing over night it was filtered, washed free of chlorides with dilute alcohol and then in alcohol and ether and dried in vacuum over sulphuric acid.

The product was a snow-white, light, bulky crystalline powder. It weighed 24 grams. It was free from chlorides and inorganic phosphate. In 0.5 gram of the substance no bases other than barium could be detected.

For analysis it was dried at 105° in vacuum over phosphorus pentoxide.

0.2931 gram subst. gave 0.0365 gram H_2O and 0.0714 gram CO_2.
0.1743 gram subst. gave 0.1144 gram $BaSO_4$ and 0.1073 gram $Mg_2P_2O_7$.
Found: C = 6.64; H = 1.39; P = 17.15; Ba = 38.62 per ct.
For tribarium inosite hexaphosphate $C_6H_{12}O_{24}P_6Ba_3 = 1066$.
Calculated: C = 6.75; H = 1.12; P = 17.44; Ba = 38.65 per ct.

The above salt was recrystallized as follows: 5 grams were dissolved in the least possible quantity of about 3 per ct. hydrochloric acid and the free acid nearly neutralized by the careful addition of barium hydroxide until a faint permanent precipitate remained. The solution was then allowed to stand over night. The substance had then separated in the same crystal form as before. It was filtered, washed free of chlorides with water and then in alcohol and ether and allowed to dry in the air.

The product was a heavy, crystalline, snow-white powder. Its dilute nitric acid solution gave no reaction with ammonium molybdate.

For analysis it was dried in vacuum over phosphorus pentoxide at 105°.

0.5772 gram subst. gave 0.0642 gram H_2O.
0.2124 gram subst. gave 0.0234 gram H_2O.
0.5130 gram subst. gave 0.0547 gram H_2O and 0.1180 gram CO_2.
0.1887 gram subst. gave 0.1348 gram $BaSO_4$ and 0.1098 gram $Mg_2P_2O_7$.
Found: C = 6.27; H = 1.19; P = 16.22; Ba = 42.03; H_2O = 11.12 and 11.01 per ct.

For heptabarium inosite hexaphosphate:

$(C_6H_{11}O_{24}P_6)_2Ba_7$ or $C_{12}H_{22}O_{48}P_{12}Ba_7 = 2267$.
Calculated: C = 6.35; H = 0.97; P = 16.40; Ba = 42.39 per ct.
For $16H_2O$ calculated = 11.27 per ct.

PREPARATION OF THE FREE ACID.

The acid was prepared from 5 grams of the first crystalline barium salt in the usual way, i. e., the substance was suspended in water and the barium removed by a slight excess of dilute sulphuric acid, filtered and the filtrate precipitated with excess of copper acetate. The copper precipitate was filtered, washed thoroughly in water, suspended in water and the copper removed with hydrogen sulphide. The filtrate was then evaporated to small bulk in vacuum at a temperature of 40° to 45° and finally dried in vacuum over sulphuric acid. There remained a practically colorless, thick syrup. The

dilute aqueous solution of the acid gave no reaction for inorganic phosphoric acid with ammonium molybdate; the concentrated aqueous solution gave a pure white, crystalline precipitate with ammonium molybdate which, standing at room temperature, remained unchanged for many months but which quickly turned yellowish in color on heating. The reactions of the acid with bases were identical with those previously reported.

For analysis it was dried in vacuum over phosphorus pentoxide to constant weight at the temperature of boiling alcohol. In drying at this temperature the color darkened somewhat.

0.3830 gram subst. gave 0.1106 gram H_2O and 0.1517 gram CO_2.
0.1839 gram subst. gave 0.1802 gram $Mg_2P_2O_7$.
Found: C = 10.80; H = 3.23; P = 27.31 per ct.
For inosite hexaphosphate $C_6H_{18}O_{24}P_6 = 660$.
Calculated: C = 10.90; H = 2.72; P = 28.18 per ct.
For phytic acid according to Neuberg, $C_6H_{24}O_{27}P_6 = 714$.
Calculated: C = 10.08; H = 3.36; P = 26.05 per ct.

CONCERNING SOME CHEMICAL PROPERTIES OF PHYTIC ACID.

SPONTANEOUS LIBERATION OF INORGANIC PHOSPHORIC ACID AT ORDINARY TEMPERATURE AND ON DRYING.

Freshly prepared phytic acid is a practically colorless syrup — especially when, in the concentration of its aqueous solution, the temperature is not allowed to rise above 50°. When the acid has been prepared from a pure salt, free from inorganic phosphate, the free acid does not give any reaction with ammonium molybdate for inorganic phosphoric acid. Whenever such colorless specimens of phytic acid are preserved for any length of time the color always darkens. The change in color is more rapid when the concentrated aqueous solution is allowed to stand exposed to the air or preserved in a well stoppered bottle, than when the acid is kept in the desiccator; but even under the latter condition the color gradually deepens to light yellow, deep yellow, light brown and finally, after several months, to dark brown or black. When the acid is dried for analysis either in vacuum or in an air bath the color darkens very materially in a short time, especially when dried at 100° or higher. When dried at a temperature of 60° or 78° in vacuum the color darkens somewhat, but very slightly in comparison with that produced at higher temperatures.

Patten and Hart[10] asserted that the acid turned dark in color on drying at 110° without undergoing any decomposition. As mentioned by Vorbrodt[11] the grounds for this statement are not

[10] *Am. Chem. Journ.* 31:570, 1904.
[11] Anzeiger Akad. Wiss. Krakau, 1910, Series A, p. 484.

quite clear. A striking change in color such as phytic acid suffers in drying or on mere keeping either in the desiccator or under ordinary conditions would very likely indicate a more or less serious decomposition.

In order to determine to what extent decomposition occurs it was decided to make a series of inorganic phosphoric acid determinations by the usual molybdate method on phytic acid preparations before and after drying. While absolute accuracy could hardly be expected or claimed for this method, at least comparable results would be obtained when the precipitations were done under similar conditions.

One portion of the acid was dried at 105° in vacuum over phosphorus pentoxide to constant weight. It was then dissolved in water, neutralized with ammonia, acidified with nitric acid, ammonium nitrate added and heated to 65°. Ammonium molybdate was then added and kept at above temperature for 1 hour. The precipitate was then determined as magnesium pyrophosphate in the usual way.

Another portion was treated in the same manner without drying, the amount of moisture found on drying as above being deducted from the weight taken.

The acid analyzed on page 32 was used for the first determinations. The fresh preparation, dried in vacuum over sulphuric acid as described, contained about 15 per ct. of water and it gave no reaction with ammonium molybdate. It was allowed to stand in the laboratory at summer temperature (about 80° or 90° Fahr.) in a loosely covered dish for three or four weeks. The color had then changed to light brown. On drying at 105° in vacuum over phosphorus pentoxide for about 24 hours to constant weight it lost about 22 per ct. of its weight, showing that it had absorbed about 7 per ct. of water during this time. The acid, page 32, contained 27.31 per ct. of phosphorus. The dried preparation gave the following as inorganic phosphate:

0.2508 gram dry subst. gave 0.0696 gram $Mg_2P_2O_7$, equivalent to 7.73 per ct. phosphorus or 28.30 per ct. of the total phosphorus was precipitated as inorganic phosphoric acid.

Before drying:

0.1889 gram (dry subst. calculated) gave 0.0039 gram $Mg_2P_2O_7$, equivalent to 0.57 per ct. of phosphorus or 2.08 per ct. of total phosphorus.

As will be noticed from the above figures, 26.2 per ct. of the total phosphorus had been hydrolyzed by drying at 105° for about 24 hours.

An old sample of phytic acid which had been kept in the laboratory for about 18 months was examined in the same manner. It was practically black in color. It lost about 22 per ct. of its weight on

drying as above for about 20 hours. After decomposing by the Neumann method it was found to contain 27.68 per ct. of phosphorus.

The dry preparation gave the following:

0.2348 gram dry subst. gave 0.0733 gram $Mg_2P_2O_7$ equivalent to 8.70 per ct. of phosphorus, or 31.43 per ct. of the total phosphorus was present as inorganic phosphoric acid.

Before drying:

0.2651 gram (dry subst. calculated) gave 0.0295 gram $Mg_2P_2O_7$ equivalent to 3.10 per ct. of phosphorus or 11.19 per ct. of the total phosphorus had been hydrolyzed in about 18 months under ordinary room conditions.

In the above case about 20.2 per ct. of the total phosphorus had been hydrolyzed on drying at 105° for about 20 hours.

A sample of the pure recrystallized barium phytate was examined for inorganic phosphoric acid in the same way. The fresh preparation gave no reaction with ammonium molybdate. After standing in the laboratory for five or six weeks the following results were obtained:

After drying at 105° in vacuum over phosphorus pentoxide 0.2108 gram subst. gave 0.0104 gram $Mg_2P_2O_7$ equivalent to 1.37 per ct. of phosphorus.

Before drying:

0.2060 gram (dry subst. calculated) gave 0.0030 gram $Mg_2P_2O_7$ equivalent to 0.40 per ct. of phosphorus.

By drying at 105° the inorganic phosphorus increased about $2\frac{1}{2}$ times.

A portion of the inorganic phosphoric acid found in the above determinations was probably due to cleavage of the phytic acid by the dilute nitric acid. Such cleavage appears to take place slowly and uniformly as shown by the following experiment: Another portion (0.1876 gram subst.) of the same barium phytate without previous drying gave 0.0022 gram $Mg_2P_2O_7$ after heating one hour with the ammonium molybdate, or 0.32 per ct. inorganic phosphorus; after heating the solution $\frac{1}{2}$ hour more 0.0010 gram $Mg_2P_2O_7$ was obtained; further heating for 1 hour gave 0.0022 gram $Mg_2P_2O_7$ and a fourth hour heating gave 0.0040 gram $Mg_2P_2O_7$. The total inorganic phosphorus obtained after heating $3\frac{1}{2}$ hours as above was 1.39 per ct. The results indicate that the cleavage under these conditions is slow and that it proceeds at a very uniform rate.

EXPERIMENT TO DETERMINE WHETHER INOSITE IS FORMED IN THE SPONTANEOUS DECOMPOSITION OF PHYTIC ACID.

The sample of old phytic acid previously referred to was used. As shown by the analysis on page 34, the preparation contained 3.10 per ct. inorganic phosphorus. Of this acid, 12.8 grams (corre-

sponding to 10 grams of the dry substance) were dissolved in about 500 cubic centimeters of water and barium hydroxide (Kahlbaum, alkali free) added to slight alkaline reaction. The precipitate was filtered and washed several times in water. The barium precipitate was reserved for special examination.

The filtrate was examined for inosite as follows: The excess of barium hydroxide was precipitated with carbon dioxide, filtered and evaporated on the water bath nearly to dryness. The residue was taken up in a few cubic centimeters of hot water, filtered from a small amount of barium carbonate and the filtrate mixed with alcohol and ether and allowed to stand for several days in the ice chest. A trace of a white amorphous precipitate had separated but absolutely no inosite crystals appeared.

In case the organic part of the phytic acid molecule, corresponding to the inorganic phosphoric acid present, had separated as inosite the above quantity, 10 grams, should have contained about 0.3 gram of inosite and such a quantity could not have escaped detection. Since no inosite could be isolated it seems fair to assume that under the above conditions of spontaneous decomposition phytic acid does not decompose into inosite and phosphoric acid but into phosphoric acid + some unknown substance.

EXAMINATION OF THE ABOVE BARIUM PRECIPITATE.

In the hope of throwing some light upon the nature of this unknown substance the barium precipitate obtained on the addition of barium hydroxide was examined as follows: It was rubbed up with about 400 cubic centimeters of 0.5 per ct. hydrochloric acid and brought into solution by the careful addition of dilute hydrochloric acid. After filtering, it was precipitated by adding an equal volume of alcohol. The precipitate was filtered, washed in dilute alcohol, dissolved in 0.5 per ct. hydrochloric acid and reprecipitated by barium hydroxide. The substance was then precipitated twice from 0.5 per ct. hydrochloric acid with alcohol, finally filtered, washed in dilute alcohol, alcohol and ether and dried in vacuum over sulphuric acid. A white amorphous powder was obtained which weighed 14 grams. It was free from chlorides and inorganic phosphate. After drying at 105° in vacuum over phosphorus pentoxide the following results were obtained.

Found: C = 7.83; H = 1.46; P = 16.72; Ba = 36.96 per ct.

The carbon found is much too high for a pure barium phytate.

PREPARATION OF CRYSTALLIZED BARIUM PHYTATE FROM THE ABOVE AMORPHOUS BARIUM SALT.

The substance was rubbed up in a mortar with about 150 cubic centimeters of cold water and allowed to stand for several hours.

The insoluble portion was changed slowly into a semi-crystalline precipitate. It was filtered and washed in water and then recrystallized as follows: It was dissolved in a small quantity of about 3 per ct. hydrochloric acid, the free acid nearly neutralized with barium hydroxide; a concentrated solution of 10 grams of barium chloride was added, the solution filtered and alcohol added gradually with constant shaking until a slight permanent cloudiness was produced. On standing the substance crystallized slowly in the usual crystal form, i. e., in globular masses of microscopic needles. After two days the crystals were filtered off, washed free of chlorides in water and then in alcohol and ether and dried in the air. Yield 4.5 grams. The substance gave no reaction with ammonium molybdate.

A further quantity of the same-shaped crystals was obtained from the aqueous solution containing the water-soluble portion of the amorphous salt by adding to it 2.5 grams barium chloride and allowing to stand over night. The balance of the water-soluble portion of the substance was recovered by precipitating with an equal volume of alcohol. The resulting precipitate was filtered, washed free of chlorides with dilute alcohol, alcohol and ether and dried in vacuum over sulphuric acid. Yield 4.1 grams.

These substances were analyzed after drying at 105° in vacuum over phosphorus pentoxide.

The recrystallized salt gave the following results:

Found: $C = 6.28$; $H = 1.28$; $P = 15.93$; $Ba = 42.18$; $H_2O = 11.81$ per ct.

The crystalline salt which separated from the aqueous solution gave

$C = 6.47$; $H = 1.23$; $P = 15.95$; $Ba = 42.77$; $H_2O = 12.62$ per ct.

These substances are therefore nearly pure heptabarium salts of inosite hexaphosphate.

Calculated for $(C_6H_{11}O_{24}P_6)_2Ba_7 = 2267$.
$C = 6.35$; $H = 0.97$; $P = 16.40$; $Ba = 42.39$ per ct.

The water-soluble substance precipitated with alcohol gave the following:

Found: $C = 8.58$; $H = 1.62$; $P = 15.86$; $Ba = 38.28$ per ct.

This substance was again treated with about 100 cubic centimeters of cold water, the insoluble portion filtered off and the filtrate, after adding 1 gram of barium chloride, precipitated with alcohol. After washing in dilute alcohol, alcohol and ether and drying in vacuum over sulphuric acid 1.4 grams of a white amorphous substance was

obtained. For analysis it was dried at 105° in vacuum over phosphorus pentoxide.

Found: C = 8.08; H = 1.68; P = 15.64; Ba = 39.75 per ct.

This water-soluble substance apparently represents a mixture of the barium salts of penta- and tetraphosphoric acid esters of inosite.

CONCERNING THE DECOMPOSITION PRODUCTS OF PHYTIC ACID AFTER DRYING AT 105° UNDER REDUCED PRESSURE.

The specimen of old phytic acid previously examined was used; 12.8 grams (corresponding to 10 grams dry acid) was dried at 105° for about 48 hours over sulphuric acid under slightly reduced pressure. It was then dissolved in about 200 c.c. of cold water. The solution was practically black in color and contained particles of carbonized material. It was decolorized by shaking with animal charcoal. The clear, colorless solution was then precipitated with barium hydroxide to slight alkaline reaction, the precipitate filtered and washed in water and reserved for examination. The filtrate and washings were freed from barium with carbon dioxide and evaporated on the water bath to dryness. The residue was taken up in a small amount of hot water and filtered. On adding a little alcohol a heavy voluminous white amorphous precipitate was produced. This was removed from the solution by adding about 3 volumes of alcohol. The precipitate settled, leaving a clear supernatant liquid; adding more alcohol produced no further precipitate. It was then filtered and washed in alcohol and the filtrate reserved

After drying, the above precipitate was obtained as a heavy, white amorphous powder. It was free from inorganic phosphorus but contained barium and after combustion the ash gave a heavy yellow precipitate with ammonium molybdate. This substance was purified as will be described later.

The filtrate from the above precipitate was again evaporated on the water bath nearly to dryness, taken up in hot water, filtered and mixed with alcohol and ether. On scratching with a glass rod a substance began to crystallize in needles. It was allowed to stand in the ice chest over night. The crystals were then filtered, washed in alcohol and ether and dried in the air. Yield 0.25 gram. The substance was recrystallized four times in the same manner and was finally obtained in colorless needles free from water of crystallization. It gave the reaction of Scherer and melted at 222° (uncorrected). It was, therefore, no doubt pure inosite. This was further confirmed by the analysis:

0.1215 gram subst. gave 0.0737 gram H_2O and 0.1780 gram CO_2.
Found: C = 39.95; H = 6.78 per ct.
For $C_6H_{12}O_6$ = 180.
Calculated: C = 40.00; H = 6.66 per ct.

PURIFICATION OF THE BARIUM AND PHOSPHORUS CONTAINING PRECIPITATE REMOVED FROM THE INOSITE SOLUTION WITH ALCOHOL.

The substance mentioned above, precipitated with alcohol, was apparently the barium salt of an organic phosphoric acid but it differed in solubility from any other salt of this nature previously observed. It was very soluble in water and was not precipitated from the aqueous solution by barium hydroxide. The dry substance weighed 1.2 grams. It was dissolved in a small quantity of water, a few drops of dilute hydrochloric acid added and 10 cubic centimeters of $^{N}/_{1}$ barium chloride. The solution was heated to boiling and alcohol added until a slight cloudiness was produced. On standing in the cold over night a small amount of a hard crust had separated on the bottom of the flask. This was removed and the solution again heated and more alcohol added when a further quantity separated in the same way. The substance was finally filtered and washed thoroughly in 80 per ct. alcohol, alcohol and ether and dried in the air. Without further purification the substance was analyzed after drying at 105° in vacuum over phosphorus pentoxide.

Found: $C = 20.03$; $H = 3.58$; $P = 8.53$; $Ba = 25.55$ per ct.

The small quantity precluded recrystallization and we are therefore unable to state whether the substance was pure. The analytical result indicates that it was a barium salt of inosite monophosphate and agrees approximately with this formula:

$C_{18}H_{35}O_{27}P_3Ba_2 = 1051$.
Calculated: $C = 20.55$; $H = 3.33$; $P = 8.84$; $Ba = 26.16$ per ct.

Such a salt could be represented by the following formula:

$$\begin{array}{l}
C_6H_{11}O_6 - P\overline{\underline{=O}}\begin{smallmatrix}OH\\O\end{smallmatrix}\\
\qquad\qquad\qquad\qquad\quad >Ba\\
C_6H_{11}O_6 - P\overline{\underline{=O}}\begin{smallmatrix}O\\O\end{smallmatrix}\\
\qquad\qquad\qquad\qquad\quad >Ba\\
C_6H_{11}O_6 - P\overline{\underline{=O}}\begin{smallmatrix}O\\OH\end{smallmatrix}
\end{array}$$

EXAMINATION OF THE PRECIPITATE PRODUCED WITH BARIUM HYDROXIDE AFTER DRYING THE ABOVE ACID.

A portion of the barium precipitate was dried in vacuum over sulphuric acid and then examined for total and inorganic phosphorus in the same way as before:

Found: Total phosphorus (by Neumann method) 9.98 per ct.
Found: Inorganic phosphorus 7.46 per ct.

As will be noticed from these figures 74.76 per ct. of the phosphorus was present as inorganic phosphoric acid.

The substance was freed from inorganic phosphate by precipitating four times with alcohol from 0.5 per ct. hydrochloric acid. After finally drying in vacuum over sulphuric acid 3.2 grams of a snow-white, amorphous powder was obtained. The substance was free from chlorides and inorganic phosphate.

It was shaken up with about 75 cubic centimeters of cold water in which the greater portion dissolved; 10 cubic centimeters of $^N/_1$ barium chloride was added and allowed to stand for several hours; the insoluble portion was then filtered off, washed free of chlorides with water and then in alcohol and ether and dried in vacuum over sulphuric acid. It weighed 0.65 gram.

The filtrate from above containing the water-soluble portion of the substance was acidified with a few drops of dilute hydrochloric acid, heated to boiling and alcohol added until a slight permanent cloudiness remained. On standing over night, a portion had separated in the form of a heavy, granular powder. Under the microscope no definite crystal form could be observed but it appeared to consist of transparent globules. It was filtered off, washed free of chlorides in 30 per ct. alcohol, alcohol and ether and dried in the air. Yield 0.67 gram. It was free from inorganic phosphate.

The mother-liquor from above was precipitated with alcohol. After settling, the precipitate was filtered, washed with dilute alcohol, alcohol and ether and dried in vacuum over sulphuric acid. Yield 1.55 grams. The substance was a snow-white, amorphous powder. It was free from chlorides and inorganic phosphate.

These three different portions were analyzed after drying at 105° in vacuum over phosphorus pentoxide.

The water-insoluble portion gave

$C = 9.40$; $H = 1.65$; $P = 13.76$; $Ba = 39.56$ per ct.

Judging by the analysis this substance consists mainly of the barium salt of inosite tetraphosphate.

The granular powder which separated from the hot dilute hydrochloric acid solution and alcohol on cooling gave the following result:

$C = 12.70$; $H = 2.40$; $P = 13.84$; $Ba = 32.29$; $H_2O = 12.77$ per ct.

This substance appears to be mainly the barium salt of inosite triphosphate, although not pure. It was mixed probably with some barium salt of inosite diphosphate.

The water-soluble portion precipitated with alcohol gave:

$C = 14.07$; $H = 2.31$; $P = 12.92$; $Ba = 33.04$ per ct.

Deducting the barium found, allowing for hydrogen and water, and calculating to the free acid these results became:

$C = 20.88$; $H = 4.11$; $P = 19.16$ per ct.

This is approximately the composition of inosite diphosphate, $C_6H_{14}O_{12}P_2 = 340$.

Calculated: $C = 21.17$; $H = 4.11$; $P = 18.23$ per ct.

That these substances, separated from the partially decomposed phytic acid, are inosite esters of phosphoric acid and not condensation or other decomposition products is evident from the fact that on complete cleavage inosite is obtained. Unfortunately the amount of each of the above substances was too small to permit of examination in this direction except the last one, viz., the water-soluble product precipitated by alcohol and which analyzed for inosite diphosphate. The remainder (0.94 grams dry substance) was hydrolyzed with dilute sulphuric acid in a sealed tube at 150°–160° for about 2½ hours and the inosite isolated in the usual way. The amount of inosite obtained was 0.28 gram or about 88 per ct. of the theory. The substance gave the reaction of Scherer and melted at 222° (uncorrected) which leaves no doubt that it was pure inosite.

It is evident that all of the barium precipitates described above are mixtures. It could hardly be expected that a complete separation into pure chemical compounds of the salts of these inosite esters could be effected by the method used. The analytical results, however, show that it is possible to isolate from partially decomposed phytic acid certain substances approximating in composition various phosphoric acid esters of inosite which on complete cleavage yield inosite just as does phytic acid itself. This fact, we believe, supports the view previously expressed that phytic acid suffers a gradual and partial decomposition, i. e., molecules of phosphoric acid are eliminated one by one. We believe also that these facts taken in connection with the formation of inosite from phytic acid on mere drying at 105° must be considered as a strong support of the theory that phytic acid is inosite hexaphosphate and not some complex compound as previously held.

ATTEMPT TO PREPARE A METHYL ESTER OF PHYTIC ACID.

The silver salt previously described as hepta-silver phytate[12] was used. Of this salt, 5.4 grams were suspended in 100 cubic centimeters of absolute methyl alcohol and 4 grams of methyl iodide (a little over the required amount) were added and the mixture shaken for several hours, the flask being protected from the light. At the end of this time the white silver phytate had changed into the yellow silver iodide.

[12] *Journn. Biol. Chem.* 12:107, 1912, and N. Y. Exp. Sta. Tech. Bull. 21, 1912.

The precipitate was filtered off and washed several times in absolute methyl alcohol and the filtrate several times evaporated in vacuum to dryness under addition of methyl alcohol for the removal of the excess of methyl iodide. The residue was dissolved in methyl alcohol and evaporated to dryness in vacuum over sulphuric acid. The substance was then obtained as a light-yellow-colored, thick syrup of faint, aromatic odor. It was strongly acid in reaction and of sharp acid taste. For analysis it was dried in vacuum at 105° over phosphorus pentoxide. It then turned very dark in color.

0.1985 gram subst. gave 0.0608 gram H_2O and 0.1016 gram CO_2.
Found: C = 13.95; H = 3.42 per ct.

This agrees with a dimethyl ester of phytic acid.

For $C_6H_{16}O_{24}P_6(CH_3)_2 = 688$.
Calculated: C = 13.95; H = 3.19 per ct.

THE WATER-INSOLUBLE SUBSTANCE WHICH SEPARATES FROM PHYTIC ACID AFTER DRYING.

As has been mentioned earlier, phytic acid, which has been dried to constant weight in vacuum over phosphorus pentoxide, is not completely soluble in water. We have observed this insoluble substance in many instances after drying phytic acid at 60°, at 78° and at 105°. It always separates, on adding water to the dry substance, in thin gelatinous plates. It appears to be practically insoluble in hot or cold water. Continued boiling in acidulated water is necessary to dissolve it. It is also insoluble in alcohol and ether.

In order to obtain some knowledge of the composition of this insoluble substance 2.7 grams of phytic acid, containing about 12 per ct. of moisture, were dried to constant weight at 105° in vacuum over phosphorus pentoxide. After treating with water the insoluble portion was filtered, washed thoroughly in water and finally in alcohol and ether and dried in vacuum over sulphuric acid. It was then obtained as a dirty gray powder which weighed 0.23 gram. It was non-hygroscopic. For analysis it was dried at 105° in vacuum over phosphorus pentoxide at which no change in color was noticeable. The substance was burned with copper oxide and the phosphorus determined in the ash.

0.2118 gram dry subst. gave 0.0569 gram H_2O and 0.1357 gram CO_2 and 0.1822 gram $Mg_2P_2O_7$.
Found: C = 17.47; H = 3.00; P = 23.98 per ct.

The quantity of the substance obtained was so small that it was only sufficient for one analysis. Of course, we are unable to state

whether it was homogeneous or not but the analytical results agree approximately with inosite triphosphate minus one molecule of water. The substance may therefore be a partial pyrophosphoric acid ester of inosite or it may represent some complex decomposition product of phytic acid.

In conclusion we present a summary of the analytical results of the preceding crystalline barium salts in comparison with the calculated percentages required for the usual phytic acid formula and inosite hexaphosphate.

Table I.— Barium Salts Crystallized from Dilute Hydrochloric acid by the Addition of Alcohol.

	Found				Calculated for	
	Cottonseed meal	Oats	Corn	Commercial phytin	Tribarium inosite hexaphosphate $C_6H_{12}O_{24}P_6Ba_3$.	Tribarium phytate $C_6H_{18}O_{27}P_6Ba_3$.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
C	6.61, 6.59	6.50	6.50	6.64	6.75	6.42
H	1.34, 1.44	1.56	1.40	1.39	1.12	1.60
P	16.91, 17.08	17.00	17.08	17.15	17.44	16.60
Ba	39.57, 38.79	38.01	39.14	38.62	38.65	36.78

Table II.— Barium Salts Crystallized from Dilute Hydrochloric Acid in the Presence of Barium Chloride.

	Found				Calculated for	
	Cottonseed meal	Oats	Corn	Commercial phytin	Heptabarium inosite hexaphosphate $(C_6H_{11}O_{24}P_6)_2Ba_7$	Heptabarium phytate $(C_6H_{17}O_{27}P_6)_2Ba_7$
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
C	6.29, 6.03	6.23	6.27	6.27	6.35	6.06
H	1.11, 1.18	1.27	1.32	1.19	0.97	1.43
P	16.54, 15.80	16.17	16.28	16.22	16.40	15.66
Ba	42.06, 42.85	41.48	42.06	42.03	42.39	40.46

TABLE III.— THE FREE ACIDS PREPARED FROM THE CRYSTALLINE BARIUM SALTS.

	Found				Calculated for	
	Cottonseed meal	Oats	Corn	Commercial phytin	Inosite hexaphosphate $C_6H_{18}O_{24}P_6$	Phytic acid according to Neuberg $C_6H_{24}O_{27}P_6$.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
C	10.68	10.82	10.86	10.80	10.90	10.08
H	3.09	3.09	3.02	3.23	2.72	3.36
P	27.66	27.12	27.22	27.31	28.18	26.05

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ORGANIC PHOSPHORIC ACIDS OF WHEAT BRAN.*

R. J. ANDERSON.

SUMMARY.

I. The results of a more extensive investigation of the organic phosphoric acid compound of wheat bran completely confirm the results previously published in Technical Bulletin 22.

Again it has been impossible to isolate any salts of phytic acid or inosite hexaphosphate.

The amorphous barium salts obtained agree in composition with those previously reported.

It appears probable, however, that these amorphous salts are not homogeneous but that they are mixtures of salts of various organic phosphoric acids. The isolation of definitely homogeneous compounds from this mixture has not succeeded.

Attention is called to the rather large content of oxalates in the crude organic phosphoric acid compound and also to the high percentage of inorganic phosphate contained in wheat bran.

II. A previously unknown organic phosphoric acid, inosite monophosphate, $C_6H_{13}O_9P$, has been isolated in beautiful crystalline form from wheat bran.

All the salts of this acid, with the exception of the lead salt, are very soluble in cold water. The alkaline earth salts are not precipitated with ammonia, differing in this respect from other known organic phosphoric acids as well as from ordinary phosphoric acid.

I. CONCERNING THE ORGANIC PHOSPHORIC ACID COMPOUND OF WHEAT BRAN. II.

(*Ninth Paper on Phytin.*)

INTRODUCTION.

It has been shown in a preliminary report[1] from this laboratory that the composition of the organic phosphoric acid isolated from wheat bran is different from that of phytic acid or inosite phosphoric acid which is present in other grains and seeds. Patten and Hart,[2] who first investigated this substance from wheat bran, came to the conclusion that it was identical with the " anhydro-oxymethylene diphosphoric acid " of Posternak. The analysis which they report

[1] *Journ. Biol. Chem.* 12: 447 (1912); and N. Y. Agric. Exp. Sta. Tech. Bull. 22. (1912).

[2] *Amer. Chem. Journ.* 31: 566. 1904.

* Reprint of Technical Bulletin No. 36, July.

of the acid preparation which they had isolated was in close agreement with the calculated composition of the above acid.

We suggested in our earlier report[3] that the acid analyzed by the above authors must have been contaminated with inorganic phosphoric acid because wheat bran contains appreciable quantities of inorganic phosphate and by their method of isolation both the organic and the inorganic phosphates would be precipitated at the same time.

The substances which we prepared from wheat bran and analyzed[4] were free from inorganic phosphate, i. e., they gave no precipitate with ammonium molybdate solution. In order to obtain preparations free from inorganic phosphate we found it necessary to precipitate the substance repeatedly from very dilute hydrochloric acid with about an equal volume of alcohol. By this process inorganic phosphates are removed because they are more soluble in the dilute acid-alcohol mixture than are the salts of the organic phosphoric acid.

In this way we obtained a crude preparation of the organic phosphorus compound which was readily soluble in cold water. Combined with it were various bases, calcium, magnesium, potassium, sodium, etc., and also some substance which contained nitrogen. By treating this crude substance in aqueous solution with barium hydroxide the above mentioned bases as well as the nitrogen-containing compound were eliminated. The resulting insoluble barium salts were amorphous and could not be obtained in crystalline form. These salts did not have the composition of barium phytates but agreed approximately with the formulas $C_{25}H_{55}O_{54}P_9Ba_5$ and $C_{20}H_{45}O_{49}P_9Ba_5$; from both salts an acid was obtained which approximately agreed with the formula $C_{20}H_{55}O_{49}P_9$. All the various preparations which were prepared in various ways agreed with the above formulas but since the substances were all amorphous we stated particularly[5] that, " The empirical formulas suggested in this paper are of course purely tentative."

Although we begged to reserve the further study of this organic phosphoric acid compound as well as the nitrogen-containing substance, Rather[6] in a recent paper reports some work on the same subject. This author had isolated some crude acid preparations from cottonseed meal and wheat bran from which silver salts were prepared. It is claimed that these silver precipitates are pure homogeneous compounds and that they are salts of an organic phosphoric acid of the formula $C_{12}H_{41}O_{42}P_9$. Since these results did not agree with those of any previous investigator in this field,

[3] Loc. cit.
[4] Loc. cit.
[5] Loc. cit.
[6] *Journn. Amer. Chem. Soc.* 35:890 (1913); and Texas Agric. Exp. Sta. Bull. 156. (1913).

the author concludes that his results are the only correct ones; owing to his superior method of isolation and purification, "purer" products had been obtained and he proposes the formula $C_{12}H_{41}O_{42}P_9$ as the correct one for phytic acid or inosite phosphoric acid.

We have already shown[7] that the above author is in error in respect to the composition of the acid in cottonseed meal. The carefully purified and many times recrystallized barium salts which we prepared from the acid from cottonseed meal had the composition of acid barium salts of inosite hexaphosphate, $C_6H_{12}O_{24}P_6Ba_3$ and $(C_6H_{11}O_{24}P_6)_2Ba_7$. The free acid prepared from these salts corresponds to inosite hexaphosphate, $C_6H_{18}O_{24}P_6$, and not to an acid of the formula $C_{12}H_{41}O_{42}P_9$.

The silver precipitates which we prepared from the above inosite hexaphosphate were pure white amorphous substances and very slightly sensitive to light. We showed,[8] however, that these silver precipitates are not homogeneous salts of inosite hexaphosphate but mixtures of more or less acid salts of the above acid.

In again taking up the investigation of the organic phosphoric acid compounds of wheat bran we have first of all critically repeated our former work. The results completely confirm those reported in our earlier paper.[9] We then repeated the work of Rather following his method of isolating the crude acid as closely as possible. The acid preparation obtained in this way was divided into two parts: One portion was used for the preparation of the silver salt as described by the above author; the other portion was transformed into the barium salt and purified in accordance with our previous method.

The barium salts which were obtained in this way were found to agree very closely in composition with those previously reported, viz.: $C_{20}H_{45}O_{49}P_9Ba_5$ and not with salts of the acid $C_{12}H_{41}O_{42}P_9$.

The silver precipitates which were obtained from the crude acid varied in composition according to the method of preparation but in one case the substance had approximately the composition stated by Rather. A simple examination of these silver precipitates quickly revealed the fact, however, that they were not "pure homogeneous salts" of an organic phosphoric acid of the formula $C_{12}H_{41}O_{42}P_9$ as claimed by the above author, but that they were largely contaminated with inorganic silver phosphate — varying from 42 to 90 per ct.

In our first report[10] on this subject we called attention to the fact that wheat bran extracts contain relatively much inorganic phos-

[7] *Journ. Biol. Chem.* **17**: 141 (1914); and N. Y. Agric. Exp. Sta. Tech. Bull. 32. (1914).

[8] Ibid., p. 149.

[9] *Journ. Biol. Chem.* **12**: 447 (1912); and N. Y. Agric. Exp. Sta. Tech. Bull. 22. (1912).

[10] Loc. cit.

phate. This part of our paper seems to have escaped the attention of Rather. This author, like Patten and Hart, has made no provision for eliminating inorganic phosphate in his method of isolating the organic phosphoric acid.

Since inorganic and organic phosphoric acids are both present in the crude acid prepared in accordance with the methods of the above authors naturally the silver precipitates obtained from such an acid neutralized with ammonia must contain both inorganic and organic silver phosphates because both are only slightly soluble in neutral aqueous solution.

Although the silver precipitates obtained from cottonseed meal and wheat bran may have approximately the same composition it is surprising that anyone could consider them identical; for so far as the most obvious physical property, viz., appearance, is concerned, they are entirely dissimilar. The silver precipitates from the inosite hexaphosphate from cottonseed meal are, as already mentioned, of pure white color and they are very slightly affected by light. The silver precipitates obtained from the acid from wheat bran, on the other hand, are only white at the moment of precipitation. These substances are either extremely sensitive to light or else the silver becomes reduced for the color rapidly darkens and finally turns quite black. Even when working under careful exclusion of direct light we have been unable to obtain a white silver preparation from the wheat bran compound.

While the amorphous barium salts prepared, as will be described later, from the organic phosphorus compound of wheat bran, show a close agreement in composition with those reported previously[11] we do not believe that they are homogeneous compounds. We have been able to separate these amorphous precipitates into several fractions some of which were semi-crystalline, but the composition was not constant. In no case, however, have we been able to obtain a trace of a salt having the composition of inosite hexaphosphate.

From the results which we have obtained it appears probable that these amorphous barium precipitates are mixtures, probably of various organic phosphoric acids. Some of these are undoubtedly lower phosphoric acid esters of inosite but it is possible that phosphoric acid esters of other carbohydrates are also present.

Neither Patten and Hart nor Rather mention the presence of oxalic acid in the preparations from wheat bran which they examined. It would seem from our results, however, that the crude substance obtained by precipitating a dilute hydrochloric acid extract of wheat bran with alcohol contains rather large quantities of oxalates.

The removal of this oxalate presented greater difficulties than the elimination of inorganic phosphate. As a barium salt oxalic acid is precipitated at every stage along with the salts of the organic phos-

[11] Loc. cit.

phoric acid. It is likewise carried down in the precipitate obtained with copper acetate because copper oxalate is very slightly soluble. The complete removal of the barium oxalate from the other mixture of barium salts was finally secured by allowing it to crystallize out from a very dilute hydrochloric acid solution of the mixed salts.

If the name "phytin" is to be applied to certain salts of inosite hexaphosphate then it is evident that wheat bran does not contain phytin for we have been unable to isolate any salt of this acid from this material.

It appears more probable that wheat bran contains several different organic phosphoric acids. So far we have been able to identify only one of these acids, viz., inosite monophosphate, a substance which will be described in a succeeding paper.

EXPERIMENTAL PART.

ISOLATION OF THE CRUDE ORGANIC PHOSPHORUS COMPOUND FROM WHEAT BRAN.

A larger quantity of the crude natural organic phosphorus compound was prepared by precipitating a 0.2 per ct. hydrochloric acid extract of wheat bran with alcohol exactly as before. From 25 kilograms of wheat bran we obtained 222 grams of the crude compound as a nearly white amorphous powder. This substance had the following composition: C = 20.21; H = 3.54; P = 13.45; Mg = 8.20; K = 5.23; Na = 2.56; Ca = trace. Nitrogen was present but it was not determined. The substance was practically free from inorganic phosphate as it gave only a trace of a yellow precipitate on warming its nitric acid solution to 65° for a longer time with ammonium molybdate.

Of the above substance, 50 grams were suspended in a small amount of water and dissolved by the addition of a little hydrochloric acid. After diluting with water it was precipitated by adding barium hydroxide in excess. It was then filtered and thoroughly washed in water.

PREPARATION OF THE NITROGEN-CONTAINING SUBSTANCE.

The filtrate from the above was freed from excess of barium hydroxide with carbon dioxide, filtered and evaporated in vacuum at a temperature of 40°–45° to small bulk and again filtered from a small amount of barium carbonate. The concentrated solution was then poured into about 500 c.c. of alcohol. It separated as a somewhat sticky mass which soon hardened. It was filtered, washed in alcohol and ether and dried in vacuum over sulphuric acid. It weighed 7 grams.

It was dissolved in a small amount of water and reprecipitated with alcohol, filtered, washed and dried as before. It was obtained as a nearly white amorphous powder. The substance was very

soluble in water and it was free from chlorides and inorganic phosphate.

It was analyzed after drying at 105° in vacuum over phosphorus pentoxide.

Found: C = 39.22; H = 5.43; N = 14.26; amino N by the Van Slyke method = 0.999; Ba = 10.43; organic phosphorus after decomposing by the Neumann method = 0.875; it also contained small quantities of magnesium, potash and soda.

PREPARATION OF THE CRUDE BARIUM SALT OF THE ORGANIC PHOSPHORUS COMPOUND.

The insoluble precipitate obtained with barium hydroxide from the 50 grams of the crude substance was again precipitated three times with barium hydroxide from 0.5 per ct. hydrochloric acid and then four times with alcohol from the same strength hydrochloric acid. The product was then a white amorphous powder and it weighed after drying in vacuum over sulphuric acid 22 grams.

A preliminary experiment showed that when this substance was dissolved in a little 0.5 per ct. hydrochloric acid and then mixed with a concentrated solution of barium chloride and allowed to stand some crystalline precipitate separated. The whole of the above barium salt was therefore dissolved in the least possible amount of 0.5 per ct. hydrochloric acid; 5 grams of barium chloride dissolved in a little water was added and the whole allowed to stand for 24 hours. A heavy white crystalline powder had then separated. This was filtered and washed several times in water and finally in alcohol and ether and allowed to dry in the air. This crystalline substance was found later to consist principally of barium oxalate. It weighed 2.75 grams which is equal to 12.5 per ct. of the barium salt used.

The filtrate, after removing the above crystals, was precipitated with alcohol, filtered, washed in dilute alcohol, alcohol and ether and dried in vacuum over sulphuric acid. It was again dissolved in the minimum quantity of 0.5 per ct. hydrochloric acid, mixed with a solution of barium chloride and allowed to stand for 24 hours. A small amount of a crystalline precipitate had separated which was filtered off. The filtrate was again precipitated with alcohol, filtered, washed and dried as before. The dry substance was again dissolved in 0.5 per ct. hydrochloric acid, barium chloride added and allowed to stand for 24 hours. The solution remained perfectly clear and no precipitate had separated. The substance was then precipitated with alcohol, filtered and washed, again dissolved in 0.5 per ct. hydrochloric acid and reprecipitated with alcohol. It was finally filtered, washed in dilute alcohol, alcohol and ether and dried in vacuum over sulphuric acid. The product was a snow-white amorphous powder, free from chlorides and inorganic phos-

phate and the following results were obtained on analysis: C = 14.98; H = 2.46; P = 11.89; Ba = 31.64 per ct.

The substance was quite soluble in cold water. It was therefore rubbed up in a mortar with a small quantity of water in which the greater portion dissolved. After standing over night the insoluble portion was filtered off, washed in water, alcohol and ether and dried in vacuum over sulphuric acid. The water-soluble portion was precipitated with alcohol, filtered, washed in dilute alcohol, alcohol and ether and dried in vacuum over sulphuric acid.

After drying at 105° in vacuum over phosphorus pentoxide the following results were obtained on analysis:

The water-insoluble substance gave: C = 12.58; H = 2.02; P = 10.06; Ba = 40.62 per ct.

The water-soluble substance gave: C = 15.54; H = 2.95; P = 12.30; Ba = 30.24 per ct.

EXAMINATION OF THE CRYSTALLINE BARIUM OXALATE OBTAINED FROM THE DILUTE HYDROCHLORIC ACID SOLUTION OF THE ABOVE BARIUM SALT.

The substance was analyzed after drying at 105° in vacuum over phosphorus pentoxide and the following result obtained: C = 6.25; H = 0.81; P = 0.95; Ba = 55.32 per ct.

The phosphorus was present in organic combination. The ash was found to consist principally of barium carbonate. When some of the substance was heated with concentrated sulphuric acid a gas was liberated which caused a white precipitate of barium carbonate when led into barium hydroxide solution.

Judging by the analysis and reactions the crystalline substance was an impure barium oxalate mixed with some of the barium salt of the organic phosphoric acid.

The crude barium salt of the organic phosphoric acid first obtained contained therefore about 12 per ct. of barium oxalate.

That the substance was barium oxalate was further confirmed by the following experiments: It was recrystallized several times from hot dilute hydrochloric acid by partially neutralizing with ammonia. It was then transformed into silver salt as follows: the barium oxalate was dissolved in a little hot dilute nitric acid, diluted with water and silver nitrate added which caused a heavy white granular precipitate. This was filtered off, washed in water, alcohol and ether and dried in the air. This substance showed all the properties of silver oxalate, viz: it was very insoluble in dilute nitric acid and on heating the dry substance it exploded. It was, however, not free from phosphorus. It contained 68.41 per ct. of silver while silver oxalate contains 71.05 per ct. of silver.

The balance of the barium salt was then transformed into calcium oxalate and the latter was recrystallized many times from boiling

dilute hydrochloric acid by nearly neutralizing with ammonia and acidifying with acetic acid. After purifying in this way 0.0826 gram of the substance was burned to constant weight in a platinum crucible. The calcium oxide remaining weighed 0.0310 grams. Calculated for the above quantity of $CaC_2O_4 + H_2O = 0.0316$ gram CaO.

The calcium oxide was dissolved in dilute nitric acid and tested with ammonium molybdate. A faint precipitate separated showing that some phosphorus remained. There appears, however, to be no doubt that the substance was a nearly pure calcium oxalate.

PREPARATION OF THE SILVER SALT OF THE ORGANIC PHOSPHORIC ACID.

The water-soluble barium salt analyzed on p. 9 was transformed into the silver salt as follows: 5 grams were suspended in water and decomposed with a slight excess of dilute sulphuric acid; the barium sulphate was filtered off and the filtrate neutralized to litmus with ammonia. Silver nitrate was added producing a pure white precipitate which however rapidly darkened in color. It was filtered, washed in water and dried in vacuum over sulphuric acid under exclusion of light. The substance was then a heavy dark-gray amorphous powder. It was free from all but traces of ammonia. For analysis it was dried at 105° in vacuum over phosphorus pentoxide under exclusion of light but it turned very dark in color.

Found: $C = 9.49$; $H = 1.48$; $P = 7.89$; $Ag = 54.85$ per ct.

The substance was free from inorganic phosphate.

As will be noticed it corresponds very closely in composition to the barium salt from which it was prepared and not to the compounds analyzed by Rather.

PREPARATION OF THE CRUDE ACID FROM WHEAT BRAN BY THE METHOD OF RATHER.

In the preparation of the acid, the directions of the above author were followed as closely as possible. The various operations may be briefly stated as follows: Wheat bran was digested in 0.2 per ct. hydrochloric acid for three hours with frequent stirring. It was then strained through cheesecloth, the residue was washed with water and again strained. The extract was centrifugalized and finally filtered. Copper acetate solution was added in excess and allowed to settle over night. The copper precipitate was freed from the mother-liquor as far as possible by the centrifuge and finally brought on the Buchner funnel and then washed several times in water. It was then suspended in water and decomposed with hydrogen sulphide, filtered and the filtrate evaporated to a thin syrup on the water-bath. This was dissolved in a small quantity of water and rendered strongly alkaline with ammonia and allowed to

stand for 24 hours. The precipitate was filtered off and the filtrate evaporated on the water-bath until the excess of ammonia was driven off. It was then diluted with water and precipitated with barium chloride in excess, filtered and washed and suspended in cold water and decomposed with slight excess of dilute sulphuric acid. After filtering, the filtrate was neutralized with ammonia and again precipitated with barium chloride. These operations were repeated three times and after finally removing the barium the filtrate was precipitated with copper acetate — this was filtered and washed until the filtrate gave no reaction with barium chloride. The copper precipitate was then suspended in water and decomposed with hydrogen sulphide, filtered and the filtrate evaporated on the water-bath to a syrupy consistency. This syrup was poured into 1,600 c.c. of alcohol and allowed to stand for the precipitate to settle. It was then filtered and again evaporated on the water-bath until the alcohol was removed. The residue was the crude acid which was obtained as a brown-colored syrup. It was diluted with water to 100 c.c. in which it formed a slightly opalescent solution of faint aromatic odor. It was divided into two parts; 75 c.c. was used for the preparation of the barium salt; of the balance, 10 c.c. was used for the preparation of the silver salt.

PREPARATION OF THE SILVER SALT FROM THE CRUDE ACID.

The 10 c.c. of the above acid solution was diluted to 100 c.c. with water and ammonia added to alkaline reaction. The excess of ammonia was boiled off, the solution cooled and silver nitrate added which caused a voluminous yellow-colored amorphous precipitate. This was filtered, washed in water and dried in vacuum over sulphuric acid. The substance was very sensitive to light, and although the desiccator was kept in a dark place the dry salt was very dark in color.

The filtrate from above was quite acid in reaction. It was neutralized with ammonia when a further quantity of a yellowish precipitate came down. More silver nitrate was added and the precipitate filtered, washed and dried as before. This was also a very dark amorphous powder. The precipitates were free from all but traces of ammonia.

These silver precipitates were analyzed after drying at 105° in vacuum over phosphorus pentoxide. The first precipitate gave: C = 2.18; H = 0.53; Ag = 71.82; total phosphorus = 7.82; inorganic phosphorus = 5.61 per ct.

The inorganic phosphorus was determined as follows: the substance was suspended in cold water and dissolved by the addition of cold dilute nitric acid and the silver precipitated with hydrochloric acid. The filtrate was neutralized with ammonia, acidified with nitric acid, ammonium nitrate and ammonium molybdate

added, and the whole kept at a temperature of 65° for one-half hour. The precipitate was then filtered and the phosphorus determined as magnesium pyrophosphate as usual.

The composition of the above precipitate is quite different from that reported by Rather. It will be noticed, however, that the inorganic phosphorus is equivalent to 75.64 per ct. of inorganic silver phosphate. The second precipitate gave the following: C = 0.98; H = 0.37; Ag = 74.37; total phosphorus = 7.15; inorganic phosphorus = 6.73 per ct. This substance accordingly contained 90.74 per ct. of inorganic silver phosphate.

PREPARATION OF THE BARIUM SALT FROM THE CRUDE ACID.

The 75 c.c. of the crude acid solution was diluted to 500 c.c. with water and precipitated with barium hydroxide in excess. The resulting barium precipitate was reprecipitated as before alternately with barium hydroxide four times and alcohol five times from 0.5 per ct. hydrochloric acid. After finally filtering, washing in dilute alcohol, alcohol and ether, and drying in vacuum over sulphuric acid, 7 grams of a snow-white amorphous powder was obtained. It was free from chlorides and inorganic phosphate.

It was analyzed after drying at 105° in vacuum over phosphorus pentoxide.

Found: C = 12.31; H = 2.21; P = 13.99; Ba = 33.45 per ct.

It will be noticed that after removing inorganic phosphate the composition of the barium salt does not agree with a compound of the formula $C_{12}H_{41}O_{42}P_9$ as proposed by Rather, but that the composition agrees closely with the compound $C_{20}H_{45}O_{49}P_9Ba_5$ which was described in the earlier paper (*loc. cit.*); calculated for the above: C = 11.79; H = 2.21; P = 13.71; Ba = 33.76 per ct.

SECOND PREPARATION OF THE CRUDE ACID FROM WHEAT BRAN BY THE METHOD OF RATHER.

A second lot of the acid was prepared from wheat bran by the same method as before except that the various concentrations were done in *vacuum* at a temperature of 40°–45° and not on the water-bath as the first time.

The silver and barium salts were prepared from the crude acid exactly as before.

The silver precipitate gave the following results on analysis after drying at 105° in vacuum over phosphorus pentoxide: C = 4.56; H = 0.77; Ag = 65.88; total phosphorus = 8.03; inorganic phosphorus = 3.15 per ct.

This approaches in composition the precipitates analyzed by Rather. However, as shown by the above content of inorganic phosphorus it contained 42.54 per ct. of inorganic silver phosphate.

The barium precipitate was free from chlorides and inorganic phosphate. It was analyzed after drying at 105° in vacuum over phosphorus pentoxide. Found: C = 11.66; H = 2.11; P = 14.14; Ba = 34.36 per ct.

This substance is therefore identical in composition with the first preparation reported above and agrees very closely with the compounds previously described.

It is clearly evident from the results recorded above that an acid, $C_{12}H_{41}O_{42}P_9$, such as described by Rather, does not exist, at least not in wheat bran or cottonseed meal. The alleged, "pure, homogeneous silver salts," analyzed by the above author must have been largely contaminated with silver phosphate and this simple impurity escaped his observation.

FURTHER PREPARATIONS OF THE BARIUM SALTS OF THE ORGANIC PHOSPHORUS COMPOUND OF WHEAT BRAN.

The 0.2 per ct. hydrochloric acid extract of wheat bran was precipitated by adding a concentrated solution of barium chloride. After settling, the precipitate was filtered and washed in dilute alcohol, alcohol and ether and dried in vacuum over sulphuric acid.

To the mother-liquor from above, barium acetate was added which caused a further precipitate. This was filtered, washed and dried in vacuum over sulphuric acid.

Total and inorganic phosphorus were determined in these precipitates as follows: Total phosphorus was determined after decomposing by the Neumann method. As inorganic phosphorus we consider the amount of phosphorus directly precipitated by ammonium molybdate from the nitric acid solution of the substance at a temperature of 65° for one-half hour.

Found in the precipitate produced with barium chloride:

Total phosphorus = 8.45 per ct.

Inorganic phosphorus = 1.55 per ct.

The result shows that 18.32 per ct. of the total phosphorus was present as inorganic.

Found in the precipitate produced with barium acetate:

Total phosphorus = 10.28 per ct.

Inorganic phosphorus = 8.63 per ct.

In this case 83.96 per ct. of the total phosphorus was present as inorganic.

The above barium precipitates were purified separately in the same way as before by repeatedly precipitating with barium hydroxide and alcohol alternately from 0.5 per ct. hydrochloric acid until pure white amorphous powders were obtained which were free from inorganic phosphate and which contained no bases except barium.

After drying at 105° in vacuum over phosphorus pentoxide the following results were obtained on analysis:

The preparation isolated from the barium chloride precipitate: Found: C = 11.53; H = 2.10; P = 14.29; Ba = 34.60 per ct.

This substance has the same composition as the precipitates obtained from the previously isolated crude acid. These various preparations were therefore mixed and treated as will be described later.

The preparation isolated from the barium acetate precipitate: Found: C = 15.22; H = 2.62; P = 12.22; Ba = 29.85 per ct.

Several other preparations were made from wheat bran in different ways. The composition varied considerably, however, as is evident from the figures given below.

One preparation gave the following:

C = 15.33; H = 2.70; P = 11.61; Ba = 32.31 per ct.

Another gave:

C = 14.62; H = 2.65; P = 12.84; Ba = 30.59 per ct.

A third preparation gave:

C = 13.94; H = 2.47; P = 13.10; Ba = 31.41 per ct.

A fourth gave:

C = 15.01; H = 2.67; P = 12.25; Ba = 30.94 per ct.

TREATMENT OF THE AMORPHOUS BARIUM SALT WITH COLD WATER.

The barium precipitates obtained from the crude acid as well as the substance isolated from the barium chloride precipitate which, as shown above, had the same composition, were mixed together. Total weight 22.5 grams. It was rubbed up in a mortar with 200 c.c. of cold water when the greater portion dissolved. The insoluble substance was filtered, washed in water, alcohol and ether and dried in vacuum over sulphuric acid. It was then treated with a second portion of 200 c.c. of cold water, again filtered, washed and dried. This insoluble residue weighed 5.75 grams. It had the following composition after drying at 105° as before:

Found: C = 9.52; H = 1.53; P = 12.89; Ba = 41.79 per ct.

The filtrate from the above, containing the water-soluble portion of the barium salt, was heated to boiling. The solution turned first cloudy but gradually a white flocculent precipitate separated which soon assumed a granular form and settled to the bottom of the flask. This was filtered, washed in boiling water, alcohol and ether and dried in the air. Under the microscope the substance showed no definite crystalline structure but consisted of fine transparent globules. It weighed 1.6 grams. It was free from inorganic phosphate.

It was analyzed after drying at 105° in vacuum over phosphorus pentoxide.

Found: C = 9.15; H = 1.79; P = 13.57; Ba = 40.43; H_2O = 9.53 per ct.
C = 8.96; H = 1.62.

The filtrate from the above was just neutralized with barium hydroxide. The white amorphous precipitate was filtered, washed in water, alcohol and ether and dried in vacuum over sulphuric acid. It weighed 17 grams. It did not contain inorganic phosphate. It was analyzed after drying at 105° as above:

Found: C = 9.19; H = 1.42; P = 11.21; Ba = 47.86 per ct.

CRYSTALLIZATION OF THE WATER-INSOLUBLE BARIUM SALT.

The water-insoluble barium salt previously analyzed, 5.75 grams, was dissolved in the minimum quantity of 0.5 per ct. hydrochloric acid and the solution heated to boiling. The solution remained perfectly clear. Alcohol was then added until the solution turned slightly cloudy. On scratching, the substance began to separate in a crystalline or granular form on the sides of the flask.

After standing over night the substance was filtered, washed in water, alcohol and ether and dried in the air.

The filtrate was precipitated with alcohol, filtered, washed and dried in vacuum over sulphuric acid. It was again dissolved in a small quantity of 0.5 per ct. hydrochloric acid, heated, alcohol added and allowed to stand as before when a further quantity of the same shaped crystalline or granular product was obtained. This was filtered, washed in water, alcohol and ether and dried in the air.

This product was a heavy snow-white crystalline or granular powder. Under the microscope it looked homogeneous and consisted of small transparent spherical globules. It was free from chlorides and inorganic phosphate. For analysis it was dried at 105° in vacuum over phosphorus pentoxide.

Found: C=9.91; H=1.83; P = 14.90; Ba = 34.75; H_2O = 12.48 per ct.

This substance was recrystallized in the same manner when it separated in the same form as before. It was again analyzed after drying as above.

Found: C = 10.06; H = 2.02; P = 15.30; Ba=33.36; H_2O=11.73 per ct.

Since this substance separated in characteristic crystalline manner and did not show any appreciable change in composition on recrystallization one might believe that it was homogeneous. We have, however, been unable to obtain any other preparation having the same composition. Numerous preparations were made which separated in exactly the same manner and form and so far as appearance is concerned they looked identical, but on analysis widely varying results were obtained.

One product gave the following:

C = 10.67; H = 2.00; P = 14.46; Ba = 35.02; H_2O = 11.97 per ct.

Another was prepared and recrystallized three times when it gave the following:

C = 11.60; H = 1.88; P = 12.48; Ba = 34.37; H_2O = 11.60 per ct.

Another preparation gave the following:
$C = 11.26$; $H = 1.58$; $P = 10.67$; $Ba = 37.81$; $H_2O = 12.00$ per ct.

Judging by these results it is evident that wheat bran contains more than one organic phosphoric acid. It appears probable that several are present and that the solubility of the salts of such acids differs so slightly that their separation is very difficult. Until definitely homogeneous products can be separated from this mixture it seems futile to develop empirical formulas; for such may be calculated for every substance analyzed. The investigation is being continued.

The author wishes to express his appreciation and thanks to Dr. P. A. Levene of the Rockefeller Institute for Medical Research, New York, N. Y., and to Dr. Thomas B. Osborne of the Connecticut Agricultural Experiment Station, New Haven, Conn., for many valuable suggestions.

II. CONCERNING INOSITE MONOPHOSPHATE, A NEW ORGANIC PHOSPHORIC ACID OCCURRING IN WHEAT BRAN.*

(Tenth Paper on Phytin.)

INTRODUCTION.

In previous reports[1] we have shown that the crude organic phosphorus compound of wheat bran[2] can be separated into two portions by treating it with barium hydroxide. The insoluble precipitate which forms under these conditions contains the barium salts of certain not yet identified organic phosphoric acids and it is free from nitrogen. By evaporating the filtrate from the above insoluble barium salts a substance is obtained which is rich in nitrogen and which also contains phosphorus in organic combination.

In the further investigation of this soluble nitrogen-containing substance it was found that its aqueous solution gave an insoluble precipitate with lead acetate. The only other salt which gave any precipitate was copper acetate and then only on warming when a

* The work reported in this paper was carried out in the I. Chem. Institut der Universität zu Berlin, Berlin, Germany.

[1] *Jour. Biol. Chem.* 12: 447 (1912); N. Y. Agric. Exp. Sta. Tech. Bull. 22 (1912), and also the preceding article.

[2] This crude compound had been prepared by precipitating the 0.2 per ct. hydrochloric acid extract of wheat bran with alcohol. The resulting precipitate was then purified by repeatedly precipitating from 0.2 per ct. hydrochloric acid with alcohol until a nearly white product was obtained which was easily soluble in cold water and which gave no precipitate with ammonium molybdate. Concerning its preparation, see the above publications.

bluish-white amorphous precipitate was produced, which dissolved completely on cooling.

The aqueous solution of the substance was therefore treated with lead acetate in excess. The resulting precipitate was filtered, washed, and decomposed with hydrogen sulphide. These operations were repeated several times until a perfectly white lead precipitate was obtained. This was finally decomposed with hydrogen sulphide and the solution concentrated in vacuum until a thick, practically colorless syrup remained. On scratching with a glass rod this immediately crystallized to a white solid mass. The substance was recrystallized from water with addition of alcohol. It was then obtained in beautiful colorless star-shaped aggregates of plates or long prisms. On slowly concentrating its aqueous solution it crystallizes in large colorless prisms with pointed ends, being often arranged in star-shaped bundles. It is, however, so soluble in water that it is more expedient to crystallize it from water with addition of alcohol.

The substance was free from bases, also free from nitrogen and sulphur, but it contained phosphorus in organic combination. Analysis showed that it was inosite monophosphate, $C_6H_{13}O_9P$, or $C_6H_6(OH)_5O \cdot PO(OH)_2$. On cleavage either with dilute sulphuric acid at 120° or higher or with 10 per ct. ammonia at 150° in a sealed tube it decomposes into inosite and phosphoric acid.

Inosite monophosphate has not been known previously, so far as we are aware, and we believe that this is the first time that it has been isolated.

In connection with the " phytin " problem it is interesting to note that a compound like inosite monophosphate exists in nature. Clarke[3] in a recent paper reports the isolation from wild Indian mustards of certain crystalline strychnine salts of what appears to be inosite tetra- and diphosphate in addition to inosite hexaphosphate. It appears probable, therefore, that in certain plants the organic phosphoric acids may be present not only as phytic acid or inosite hexaphosphate, $C_6H_{18}O_{24}P_6$, but also as lower phosphoric acid esters of inosite. From wheat bran, for instance, we have been unable to isolate any inosite hexaphosphate. The insoluble barium salts of the organic phosphorus compound obtained from this material are evidently mixtures of various organic phosphoric acids, either lower inosite phosphates or phosphoric acid esters of other carbohydrates. However, we have been unable, so far, to separate any homogeneous substance from this mixture.

The isolation of inosite monophosphate only succeeded because its properties are so different from those of the other organic phosphoric acids which exist in wheat bran — for instance, its easily soluble barium salt permitted its separation from the other acids which give insoluble barium salts.

[3] *Jour. Chem. Soc.* **105:** 535. 1914.

At present we have no data as to the quantitative percentage of inosite monophosphate in wheat bran. We hope, however, to make some determinations in this direction later. We wish to reserve the further study of the physiological properties of this substance in connection with the general investigation which is being carried out at this Station. We also beg to reserve the study of the cleavage products obtained under different conditions and other derivatives of inosite monophosphates.

EXPERIMENTAL PART.

The crude nitrogen-containing substance[4] was dissolved in water and a concentrated solution of lead acetate added in excess. The resulting precipitate was filtered, washed thoroughly in cold water and then suspended in hot water and decomposed with hydrogen sulphide. The lead sulphide was filtered off and the filtrate boiled to expel hydrogen sulphide. The solution was then strongly acid to litmus and it had a sharp acid taste. It was again precipitated as above three times with lead acetate. The pure white colored lead precipitate which was finally obtained was decomposed with hydrogen sulphide. The filtrate was concentrated in vacuum at a temperature of 40°–45° and then dried in vacuum over sulphuric acid until a thick, practically colorless syrup remained. On scratching with a glass rod this immediately began to crystallize, forming a white, solid mass. It was very soluble in water, but insoluble in alcohol. It was extracted several times with 95 per ct. alcohol, filtered and washed in absolute alcohol and ether and allowed to dry in the air. For recrystallization it was dissolved in a small quantity of water and absolute alcohol added until the solution turned slightly cloudy. On scratching, the substance began to crystallize. After standing in the ice chest over night it had separated in large colorless plates or prisms arranged in star-shaped aggregates. It was recrystallized a second time in the same manner.

The substance was free from bases and also free from nitrogen and sulphur, but it contained organically bound phosphorus. The aqueous solution gave no precipitate with ammonium molybdate on being kept at a temperature of 65° C. for some time but after decomposing by the Neumann method it gave an immediate precipitate of ammonium phosphomolybdate with this reagent.

The substance has no sharp melting point. When rapidly heated in a capillary tube it softens at 200° C. and decomposes under effervescence at 201°–202°; when slowly heated it begins to soften at 188° and melts under decomposition at 190°–191° (uncorrected).

It is optically inactive. A 10 per ct. solution in a 1 dcm. tube shows no rotation.

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[4] From its isolation from wheat bran see *Journ. Biol. Chem.* 12: 456 (1912); N. Y. Agric. Exp. Sta. Tech. Bull. 22, p. 10 (1912), and also the preceding article.

For analysis it was dried at 100° in vacuum over phosphorus pentoxide but it did not lose in weight.

0.1550 gram subst. gave 0.0749 gm. H_2O and 0.1566 gm. CO_2.
0.0766 gram subst. gave 0.0325 gm. $Mg_2P_2O_7$.
Found: C = 27.55; H = 5.40; P = 11.82 per ct.
For inosite monophosphate, $C_6H_{13}O_9P = 260$.
Calculated: C = 27.69; H = 5.00; P = 11.92 per ct.

Titrated against barium hydroxide, using phenolphthalein as indicator, it forms the neutral barium salt, $C_6H_{11}O_9P$ Ba.

0.1985 gram subst. required 7.6 c.c. $\frac{N}{5}$ $Ba(OH)_2$.
For $C_6H_{11}O_9P$ Ba, calculated: 7.6 c.c. $\frac{N}{5}$ $Ba(OH)_2$.

PROPERTIES OF INOSITE MONOPHOSPHATE.

The acid is very soluble in water. The aqueous solution shows a strong acid reaction to litmus and it has a sharp, somewhat astringent, acid taste. It is insoluble in alcohol, ether and the other usual organic solvents.

Its aqueous solution gives no precipitate with barium hydroxide or with calcium or barium chloride; ammonia produces no precipitate in these solutions but the addition of alcohol causes white amorphous precipitates. Silver nitrate produces no precipitate even in a solution neutralized with ammonia. When alcohol is added to the solution containing silver nitrate a white amorphous precipitate is produced which dissolves on warming; on cooling the silver salt separates in small, round crystal aggregates. It gives no precipitate with ferric chloride or mercuric chloride nor with copper sulphate. In the cold no precipitate is produced with copper acetate, but on warming this solution a bluish-white precipitate separates which again dissolves completely on cooling.

With excess of lead acetate a white, heavy amorphous precipitate is formed which is but slightly soluble in dilute acetic acid, but readily soluble in dilute hydrochloric or nitric acid. Ammonium molybdate produces no precipitate in either dilute or concentrated aqueous solutions.

The acid crystallizes without water of crystallization from either water or dilute alcohol.

The aqueous solution of inosite monophosphate does not precipitate egg albumen, differing in this respect from phytic acid.

CLEAVAGE OF INOSITE MONOPHOSPHATE INTO INOSITE AND PHOSPHORIC ACID.

I. ACID HYDROLYSIS.

The acid, 0.35 gram, was heated in a sealed tube with 15 c.c. of 3 per ct. sulphuric acid to 120°–125° for about 3½ hours. After cooling, the liquid was of a pale straw color. The sulphuric and phosphoric acids were precipitated with barium hydroxide and the

excess of barium hydroxide removed with carbon dioxide. The filtrate was evaporated to dryness on the water-bath. The residue gave no precipitate with ammonium molybdate, but after decomposing by the Neumann method, a heavy precipitate of ammonium phosphomolybdate was obtained showing that only a portion of the acid had been hydrolyzed under the above conditions. The residue, however, contained some inosite which was isolated as follows: The substance was taken up in a few cubic centimeters of hot water, a little more than an equal volume of alcohol was added which caused a voluminous white amorphous precipitate consisting of the barium salt of the unchanged inosite monophosphate. After filtering, the precipitate was again treated with water, again precipitated with alcohol and filtered. The filtrates were evaporated on the water-bath, taken up in a little water and the inosite brought to crystallization by the addition of alcohol and ether. It crystallized in the usual needle-shaped crystals. After standing several hours in the ice chest the crystals were filtered, washed in alcohol and ether and dried in the air. Yield 0.06 gram. It gave the reaction of Scherer and melted at 224° C. (uncorrected).

II. ALKALINE HYDROLYSIS.

Another portion of the acid, 0.4 gram, was heated in a sealed tube with 10 c.c. of 10 per ct. ammonia for six hours to 120°. The solution then contained some free phosphoric acid as it gave a precipitate with ammonium molybdate but the greater portion of the acid remained unchanged. It was found impossible to isolate any inosite from this reaction mixture.

The residue was therefore again heated in a sealed tube with 10 per ct. ammonia for about $4\frac{1}{2}$ hours to 150°. In this case complete hydrolysis had taken place, and after isolating the inosite in the usual way 0.15 gram was obtained. This was recrystallized three times from dilute alcohol with addition of ether and was then obtained in colorless needles free from water of crystallization. It then melted at 224° C. (uncorrected), and it gave the reaction of Scherer. The identity of the substance was further confirmed by the analysis.

0.1206 gram subst. gave 0.0755 gm. H_2O and 0.1761 gm. CO_2.
Found: $C = 39.82$; $H = 6.97$ per ct.
For $C_6H_{12}O_6 = 180$.
Calculated: $C = 40.00$; $H = 6.66$ per ct.

The author wishes to express his appreciation and thanks to His Excellency Prof. E. Fischer and to Prof. H. Leuchs for the kind interest which they have shown in the work reported in this paper.

REPORT

OF THE

Department of Entomology.

P. J. Parrott, *Entomologist.*

Hugh Glasgow, *Associate Entomologist.*

H. E. Hodgkiss, *Assistant Entomologist.*

B. B. Fulton, *Assistant Entomologist.*

F. Z. Hartzell, *Associate Entomologist.*
(Connected with grape culture investigations.)

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REPORT OF THE DEPARTMENT OF ENTOMOLOGY.

THE CRANBERRY TOAD-BUG.*

F. A. SIRRINE AND B. B. FULTON.

SUMMARY.

Cranberry growers on Long Island have been troubled by a peculiar dying of the new growth of the vines, caused by the cranberry toad-bug (*Phylloscelis atra* Germ.) of the family Fulgoridae. The shape of the insect and its posture when at rest suggested its popular name.

The cranberry appears to be the only host plant of this insect. When it feeds on the new growth both branch and fruit are killed, but if it feeds on the old wood the berries and branches beyond the feeding point are shriveled and dwarfed. Many bogs are practically free from the insects, but on one at Riverhead and one at Calverton, the yield from certain varieties has been reduced to one-half or one-fourth of a normal crop.

There is but one brood of the insects during the year. The egg is elongate-oval in shape, with a short stalk at one end. The egg-laying period extends from September 1 to the middle of October. The female runs over the ground, dragging the egg by the stalked end, so that its viscid surface becomes covered with sand and dirt before it is dropped. Hatching begins on June 25 to 30 of the following summer, and a few may not hatch until early in August. Nymphs usually group together to feed, and may live a long time on the same branch if not disturbed. The insect has five nymphal instars. The first adults appear about the first of August, the males maturing first.

The nymphs secrete a white, cottony substance which adheres to the branch, and this, with the excrement and molted skins, is more easily detected than the insect. The first symptom of injury is the closing in toward the branch of the leaves on the new growth.

Tests were made of two methods of control, flooding and spraying. Of these, the former is recommended where it is possible,

* Reprint of Bulletin No. 377, March.

and should be practised between August 1 and 15. All weeds on and near the bog should be cut. A cloudy period should be selected, and a good wind favors efficient control. Bugs on the surface of the water should be sprayed with kerosene. All grass, weeds, and drift on the shore should be burned with a burning torch-spray.

Spraying is the only possible remedy on "dry bogs." When the vines contain much old wood they should be mowed at the usual season for cutting and, between August 1 and 15, sprayed with soap solution, 1 pound to 7 gallons, making two applications, using 200 gallons per acre.

INTRODUCTORY NOTES.

Prior to and during the summer of 1911 a cranberry bog at Calverton, L. I., managed by Mr. R. C. Brown, of Riverhead, suffered from a peculiar dying of the new growth of the cranberry vines. This trouble was at first ascribed to "cranberry scald" and "cranberry rot," but the treatment recommended for the control of these diseases — mowing the vines, resanding, fertilizing with fish scrap and the use of other measures to promote new growth of the vines — did not afford any protection to the plants. Mr. Brown reported the damage as great in 1912, after using the above measures, as in the previous year.

The writers had no part in the above diagnosis of the trouble, nor in the recommendations given for treatment; but they assisted Mr. Brown in planning his stationary spraying outfit for preventing the supposed fungus troubles. Upon assembling the equipment they requested Mr. Brown to notify them the following year as soon as any of the injury was noticeable on the bogs. Early in July Mr. Brown reported that a diseased condition of the vines was again making its appearance. The vines were inspected July 10, 1912, and, after a careful search by the senior author, patches of a white, powdery substance were found on branches and on the ground. By using caution in moving the branches, and with the aid of a hand lens a small nymph of some hemipterous insect was found, which proved a very active jumper. The life history of this insect was followed in the field and in breeding cages until adults were obtained. These were kindly identified by Mr. E. P. Van Duzee as *Phylloscelis atra* Germ., which belongs to a group of homopterons known as the Fulgoridæ or Lantern-fly Family. The

shape of this insect and its posture, when at rest on the vines, remind one of a toad, and for this reason the popular name — "cranberry toad-bug"— is suggested for this species. However this should not be confused with the name "toad-shaped bug" which has been given to a group of hemipterous insects belonging to the family Galgulidæ.

NOTES ON THE INSECT.

HISTORY OF THE SPECIES IN THE UNITED STATES.

This species has in the past attracted but little attention from economic and systematic workers. The earliest published accounts of insects injurious to cranberries, by Dr. A. S. Packard,[1] include nothing relating to any of the homopterous bugs. Dr. Saunders [2] gives a "spittle insect" (*Clastoptera proteus* Fitch) as a cranberry pest. In 1884 Dr. J. B. Smith [3] collected a Fulgorid (*Amphiscepa bivittata* Say) on cranberry bogs. He says, "This little insect, while found on every bog, does little injury." Again in 1890 [4] he mentions three leaf-hoppers as taken on cranberry bogs, of which he says: "These species puncture the vines and live upon the sap, but I have not seen any injury that could be attributed to them."

In the Annual Report of the New Jersey State Museum for 1909, Dr. Smith gives the Fulgorid *Phylloscelis pallescens* Germ. as taken on cranberry bogs. In the same publication he lists *Phylloscelis atra* Germ. and *Amphiscepa bivittata* Say, but does not state that they were taken on cranberry bogs.

The Wisconsin Agricultural Experiment Station has published three bulletins [5] on cranberry culture, in none of which is mention made of any injury to cranberry vines by either Fulgorids or Jassids.

In 1908 the Massachusetts Agricultural Experiment Station published Bulletin 126 on "How to Fight Cranberry Insects," by H. J. Franklin, but no reference is made to any of the above insects as attacking the cranberry.

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[1] Rept. U. S. Geol. Surv. for 1876., pp. 521–531.
Trans. Wis. State Hort. Soc. 10:313–322. 1880.

[2] Ins. Inj. to Fruits, p. 374. 1883.

[3] U. S. Dept. Agr., Ent., Bul. 4, p. 30. 1884.

[4] N. J. Agr. Expt. Sta. Spl., Bul. K., p. 42. 1890.

[5] Wis. Agr. Exp. Sta. Buls. 35 (1893), 119 (1905) and 159 (1908).

Although the cranberry toad-bug was collected on cranberry bogs prior to 1900, and described as early as 1839, the indications from published accounts of cranberry insects are that the descriptions of this pest were made from migrants which were collected on other plants than the cranberry, leading therefore to the conclusion that the species was of no economic importance. In cases where it produced injury the trouble was, as in the foregoing outbreak, laid to other causes.

The wilting of new growth shown on Plate VI of Dr. C. L. Shear's work[6] on "Cranberry Diseases" resembles the characteristic injury of the cranberry toad-bug; though the same condition might result from the drying of the foliage before photographing, or, as indicated, from some disease.

ECONOMIC IMPORTANCE.

Unlike most species of the Fulgoridæ, this bug apparently confines its feeding to one plant — the cranberry. The insects do not appear to be widely disseminated, and many bogs are practically free from them; but on two Long Island bogs, one at Riverhead and one at Calverton, the crop of fruit from such varieties as Centennial, Matthews, Howe and Early Black has been greatly reduced, the loss varying from one-half to three-fourths of a normal crop during the past three years. Wherever the insects feed on the new growth both new shoots and fruit are killed outright; while if they happen to feed only on the old wood the berries on all branches beyond the feeding point are shriveled and dwarfed, as shown in Plate XII, fig. 2, d; c shows normal fruit. Plate XVIII, fig. 1, b also shows an uninjured branch with fruit.

The amount of damage these insects do can be expressed roughly by the loss in yield on bogs where the pests have become established. On the Brown bog at Calverton, L. I., the yield on an affected tract of Howes, of about 5 acres, for four years was as follows: 1910, 800 bushel crates; 1911, 500 bushel crates; 1912, 292 bushel crates, and in 1913, after treatment, 1,350 bushel crates. A small section of Early Blacks adjoining the Howes yielded as follows: 1912, 36 bushel crates; 1913, after treatment, 139 bushel crates.

Expressed in barrels, after sorting, and in money values these yields would be approximately as follows from five acres of Howes:

[6] U. S. Dept. Agr. Pl. Ind. Bul. 110 (1907).

1910	200 bbls.	$1,800
1911	125 "	1,125
1912	73 "	657
Average of 3 years before treatment		$1,194
1913	350 barrels after treatment	3,150
Gain by treatment		$1,956
Gain per acre		$391.20

On the small tract of Early Blacks adjoining the Howes the yields were as follows:

1912	9 bbls.	$81.00
1913	34¾ " (after treatment)	312.75
Saving due to treatment		$231.75

SYNONOMY

The generic name, Philloscelis, was given to this insect in 1839 by Germar [7] who described two species from a collection of two specimens, both of which had short wing covers and abortive wings. In 1907 Van Duzee [8] described the alate forms of both species basing the distinction of the two on the venation of the elytra. Osborn [9] in 1904 described the alate form of *P. atra* illustrating the venation of the wings.

In our collections of this insect we have obtained specimens that not only accord with the descriptions of *atra* and *pallescens* but others also that are intermediate forms between these species. We are not stating positively that only one species exists, but until more marked and constant characters can be found for separating the different forms we see no reason for listing them as separate species or for separating the insects into varieties. Since Mr. Van Duzee has pronounced the specimens sent to him as *P. atra*, we have retained that name.

[7] *Ztschr. Ent.*, 1839, pp. 191–2.
[8] *Proc. Acad. Nat. Sci. Phil.*, 1907, pp. 471–472.
[9] *Ohio Naturalist*, 4:93–4.

DESCRIPTION OF LIFE STAGES.

Description of egg: (Fig. 15.) The main body of the egg is an elongate oval, about .8 mm. in length and .4 mm. in width. One end is slightly narrower and bears a short, slightly curved stalk or peduncle, which is from .16 to .19 mm. in length. The color is a distinct yellow when the egg is first deposited, but soon becomes a light yellow or straw-color. The surface is minutely roughened so as to appear only semi-glossy, and when first laid is somewhat viscid. When placed in water the eggs sink readily.

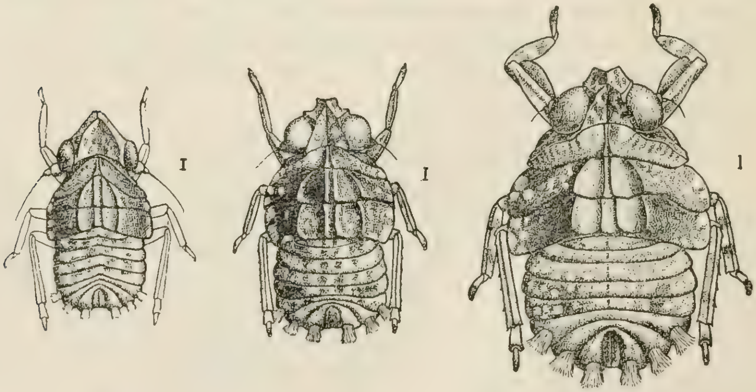
FIG. 15.—EGG FROM BODY OF FEMALE.

FIG. 16.—EGG COVERED WITH SAND AND DIRT (usual condition).

Description of nymph. First instar: (Fig. 17, a.) Vertex of head elongate; disk depressed and bounded by lateral carinae which unite at the apex. Front with a broad groove bounded by parallel carinae which also meet at the apex. Apex with a short median carina. Below, the head is prolonged posteriorly; beak apparently arises from between the anterior coxae. *Thorax* broad. Sides of pronotum with anterior edge bent abruptly downward behind the eyes, these parts in later stages becoming rounded lateral plates. Each segment of thorax with a pair of carinae close to median line, and the meso- and metathorax have another pair more widely separated. Abdomen rounded; with eight complete segments. The last three are strongly bent forward in the middle, the last being shaped like an inverted U, and each bears a small gland at the lateral edge, which develops a brush of white waxy filaments.

Color.— Head with pale ground color and brown markings. Thorax dark brown above; paler near median line. Abdomen mostly pale. The first five segments may be specked with brown or have white spots on a pale brown ground color. Legs white. Antennae pale brown.

Size.— Length about 1 mm.; width about .5 mm.



a. b. c.

FIG. 17.— DORSAL VIEW OF NYMPH OF CRANBERRY TOAD-BUG. a, First instar; b, second instar; c, third instar.

Second instar: (Fig. 17, b.) Vertex not so much prolonged. Median carina at apex reduced so that the paired carinae of vertex and front meet at nearly the same point. Front with another pair of carinae just in front of eyes, parallel to the inner pair and joining the carinae of the vertex above the eyes. Sides of pronotum bent downward so that the anterior portion appears as a lateral sclerite behind the eyes. Front femora and tibiae laterally compressed.

Color.— Head white with brown specks. Front with two fuscous lines between inner carinae. Thorax white between the outermost pair of carinae and thinly specked with brown. Outer part plain fuscous with a few white spots near the carinae and outer edge. Abdomen brown and white mottled. Under parts white, thinly specked with pale brown. Legs white with a few pale brown bands. Tips of tarsi dark.

Size.— Length 1.3 mm.; width .75 mm.

Third instar: (Fig. 17, c.) Vertex shorter. Front with a small median carina. Sides of meso- and metanotum directed posteriorly forming short wing-pads, the first barely overlapping the second. Fore femora compressed and with a rudimentary foliaceous extension on the upper and lower edge.

Color.— Head and thorax fuscous, with roundish white spots mostly clustered around median area and outer edge. Abdomen mottled; where fuscous predominates, the white takes the form of round spots. Underside mostly pale. Legs spotted and banded with fuscous.

Size.— Length 1.8–2.3 mm.; width 1.0–1.3 mm.

Fourth instar: (Plate XI, fig. 1.) Sides of pronotum form roundish lateral plates back of antennae and above front coxae, and separated from dorsal part of pronotum by two oblique parallel carinae which run about in line with the edge of the mesothoracic wing-pad. Wing-pads well developed, the first distinctly overlapping the second. Foliaceous extensions of the front femora well developed. Brushes of waxy filaments not as conspicuous as in previous instars.

Color.— Upper parts and sides of thorax fuscous marked with roundish white spots. Under side of abdomen pale. Tips of wing pads with large white spots, bases plain fuscous. White predominates on hind portion of abdomen. Legs fuscous, with numerous white spots. Tarsi white at base.

Size.— Length 2.8–3.2 mm.; width 1.7–2.0 mm.

Fifth instar: (Plate XI, fig. 2.) Vertex relatively short. Outer pair of frontal carinae most prominent; median as prominent as inner pair. Front wing-pad laps over the second nearly to its tip. Secretion from abdominal glands inconspicuous.

Color.— Ground color of different parts varies from pale brown to fuscous or black; everywhere specked with numerous small white spots. Lateral lobe of pronotum with a large black patch covering the upper half and extending along the front edge of pronotum toward the median line. Hind edge of metathorax with a large transverse black blotch on each side of median line. Fourth abdominal segment with an ill-defined median black blotch. Fifth segment with a pair of black spots half-way between median line and sides.

Size.— Length 3.5–3.8 mm.; width 2.3–2.8 mm.

General characters of adult.— (Plate XI, fig. 3). The adults are characterized by having a short vertex, prominent eyes and broad leaf-like front femora. The insects normally sit with the tip of the abdomen close to the branch and the head held away so that the long axis of the body makes an angle of about 45 degrees with the branch. The hind legs are doubled up tightly, the tibiae fitting into grooves in the distal part of the femora. The former are armed with a row of 4 to 6 spurs on the outer carina and a crown of eight stout spurs on the tip. These spurs give a firm contact with the

supporting surface, which, with the structure and position of the tibiae and femora, make the hind legs powerful jumping organs. The adults are extremely variable in size, structure, color and habits. (Fig. 18). Our collections and notes show that the first individuals to reach maturity are males with abortive wings and short elytra. All the early maturing individuals, both males and females are dark colored, occasionally jet black and are sometimes without white markings. Late in the season males and females, both short- and long-winged forms, are lighter colored, some being even light brown. An occasional male and a larger number of females develop complete wings for migration, and these are the forms which are generally obtained by collectors on various kinds of vegetation. However, the major portion of the insects have abortive wings and remain on the bogs. As far as observed only the dark-colored alate forms were able to fly. The light brown females, with both pairs of wings well developed, but possessed of little or no power of flight, have very indistinct veins on the elytra.

FIG. 18.— CRANBERRY TOAD-BUG. Diagrammatic drawings of elytra, showing variations in size and venation. a and b, alate forms; c, abortive-winged form. (10 diameters.)

The following is a detailed description of the adult:

Adult.— Vertex short and broadly rounded; disk depressed but slightly raised in center; side and hind margins elevated; bounded in front by a pair of carinae which meet at the apex in an obtuse angle. Front prominent; sharply separated from the genae by parallel carinae; with distinct median and an obscure inner pair of carinae. Beak extends downward and backward between the front coxae. Eyes prominent, usually brownish, revealing at times whitish markings.

Pronotum short; sides extended downward to base of front coxae and expanded into large rounded lobes. Scutellum broadly triangular. Front wings coriaceous. In short-winged forms they are convex or spoon-shaped, but in long-winged forms are more flat. Veins run parallel and branch mostly near the base and with two or three series of cross veins near apex. There is however no constancy in the venation of either long- or short-winged forms. Median portion of space between

veins slightly elevated, more prominently in abortive-winged forms where it appears like a supernumerary vein. Hind wings thin and delicate. In long-winged forms they reach nearly to tip of fore wings, and in short-winged forms are abortive. Front femora broad and foliaceous. Hind femora grooved on the distal part to receive the tibiae. Tibiae all triangular. Hind tibiae with a row of four to six spurs on the outer carina and a row of eight stout spurs across the apex on the under side. Tarsi three jointed; with two claws or hooks. The front and middle tibiae are covered with stiff hairs.

Color.— Dark forms: Ground color fuscous or black. Head, thorax and legs specked with small, round white spots. Face with an oblique white band extending from base of beak up and back across gena and lateral lobe of pronotum. Elytra entirely black and generally with scattered translucent spots along the veins. Early in the fall some of the short-winged males show no white markings except a trace on the face, but the major portion of them have the white face bands and at least one white spot on front femora. Elytra of alate forms have fewer translucent spots.

Light forms: Ground color medium to dark brown with numerous whitish spots and face bands as above. Elytra pale to dark brown; translucent spots may be present but are not conspicuous.

Size.— Length 4.0–5.5 mm.

LIFE HISTORY NOTES.

Under the conditions of confinement in breeding cages, the females during the period of oviposition were very uneasy, dropping to the ground, running over it to another branch of the same plant, or even to another plant, dragging an egg by the stalked end, so that small particles of sand would adhere to it, often completely covering it. (Fig. 16). Generally the egg was lost on the ground. If not, the female rubbed it from the ovipositor against a branch or a leaf, from which the egg soon fell to the ground. The particles of sand undoubtedly aid in preventing the floating of the eggs when bogs are flooded, which generally covers the period from November 15th to May 1st. Studies conducted by means of breeding cages indicate that the eggs may be deposited over a period beginning with about the first of September and lasting to the middle of October. Under natural conditions the insect baffled all attempts to study its habits during the egg-laying period.

As far as observed, none of the eggs hatch until about June 25 to 30. The earliest date on which nymphs have been found was June 29, while the occurrence of nymphs of the first instar after August 1, combined with the fact that the bogs became pretty well infested after flooding as late as July 20, would indicate that a large portion of the eggs hatch after July 15. On sections of bogs where the vines are very heavy and shade the ground the eggs do not hatch as early as in more open spaces; the difference in time

is from one week to ten days. A few eggs, moreover, do not hatch until early in August.*

As soon as hatched, the young nymphs crawl to the cranberry vines, insert their beaks into the bark and commence feeding. Sometimes a single nymph will be found on a branch, but usually from two to six are grouped near together to feed. Not infrequently as many as three cast skins have been observed in the immediate vicinity of one insect, which indicates that individuals of the species may remain feeding on one branch for considerable portions of time unless disturbed. The cast skin may be easily mistaken for the bug itself, and when numbers of them are massed together they present the appearance of a colony of the living insects. In 1912 the first winged specimens, all of which were males, were observed on August 1, while in 1913 winged specimens were obtained on August 2. Mating of the insects was first observed during 1913 on September 14 and insects in copula were detected as late as October 15. In the observation cages, the males died a short time after mating, while the females disappeared soon after the conclusion of the period of egg-laying.

SOME HABITS OF THE INSECT.

As the nymphs feed and grow they secrete a pulverulent, cottony substance, so that the bodies of the insects appear to be covered with small tufts of white hairs. This secretion, instead of forming long tufts as is natural with some species of bugs, breaks away as a powdery substance which adheres to the branch where the insects feed and to surrounding objects, or may even appear on the ground. This substance is secreted from glands on the body and is not the excreta of the insect. The latter looks like fly specks when it occurs on the leaves, even on the old dead leaves. It resembles the perithecia of the cranberry-rot fungus and may quite easily be mistaken for them.

The molted skins adhere to the branch where they are shed. Usually it is easier to find the cottony secretion and molted skins than to find the nymphs themselves (Plate XII, fig. 1), as the latter have a habit of dodging around to the opposite side of a branch

* Bog No. 1 was flooded June 13 and 14, before blossoming, for cranberry worms, and left under water forty-eight hours. No toad-bugs in any stage of development came ashore at this time.

Bog No. 2 was flooded July 23. On August 6, young nymphs were found on it.

Plate XI.—Stages of Cranberry Toad-bug.
1 (upper), Fourth instar; 2 (center), fifth instar; 3 (lower), adult.

Plate XII.— Cranberry Toad-bug and Its Work on Plants.

1, a, Nymphs; b, cast skins and powdery secretion on stem of plant; 2, c, normal cranberry branches and fruit; d, branch and fruit injured by the toad-bug.

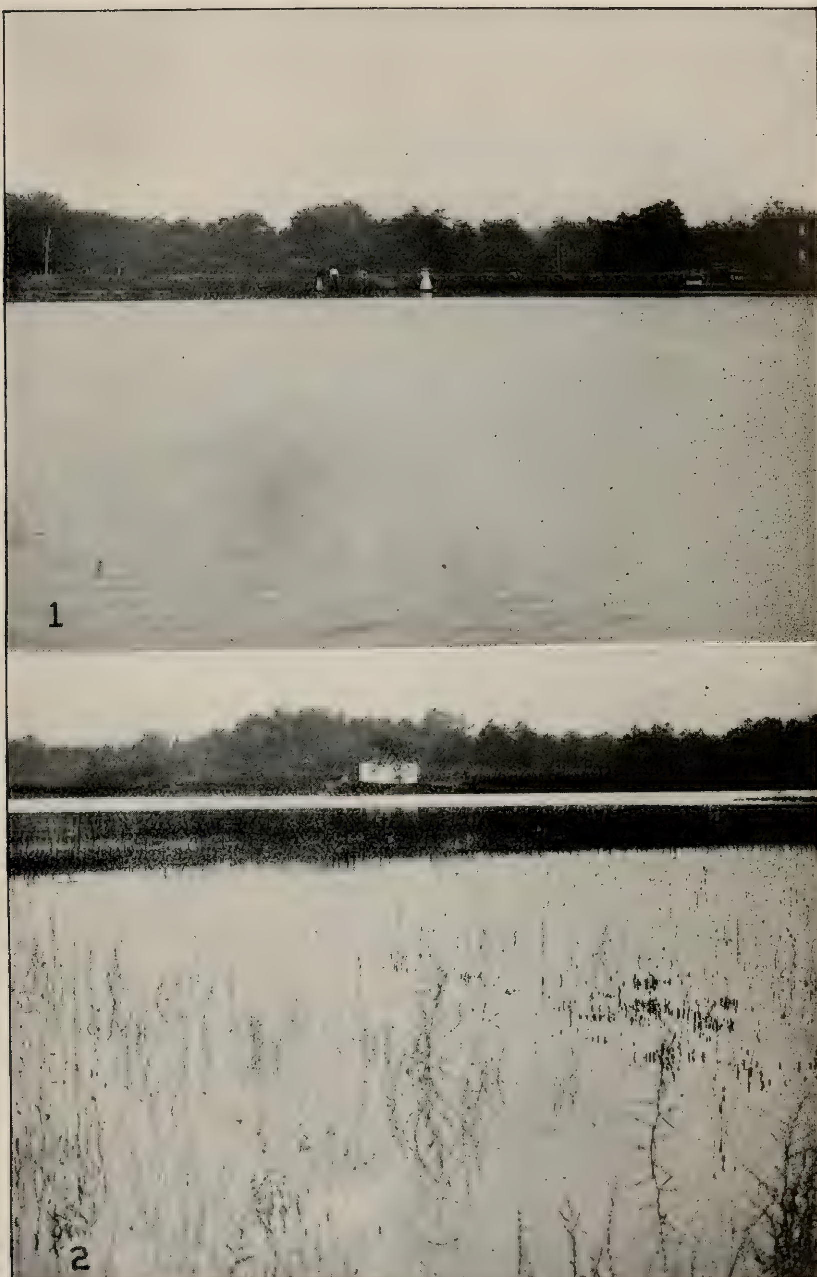


Plate XIII.— Flooding for Control of Cranberry Toad-bug.
1, Properly flooded bog; 2, improperly flooded bog.

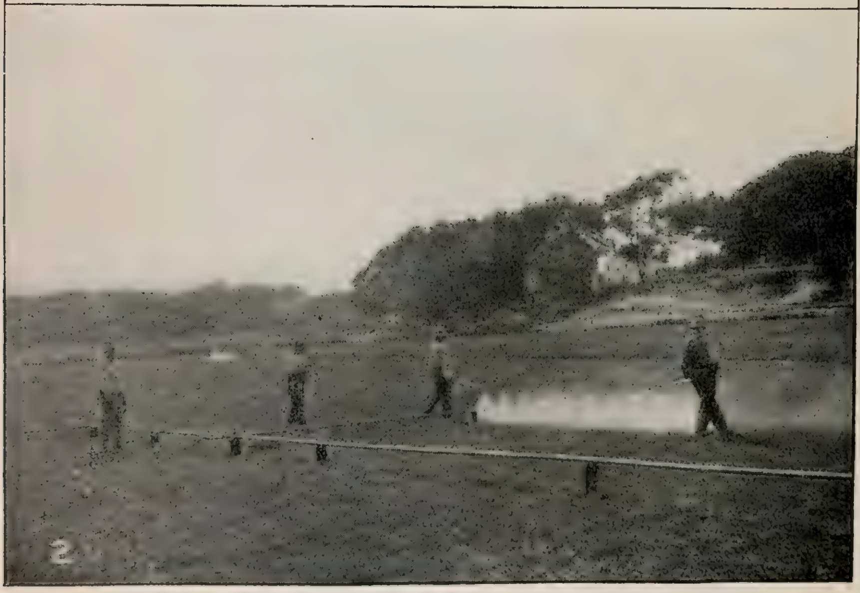


Plate XIV.—Controlling Cranberry Toad-bug.

1, Burning drift and grass with kerosene-spray torch on margins of bog after flooding; 2, piping and aluminum sprayboom, for use on large bogs.

Plate XV.—Controlling Cranberry Toad-bug.

Burning debris and toad-bugs on surface of water with a kerosene-spray torch; an unsatisfactory method.

Plate XVI. — Controlling Cranberry Toad-bug.

Spraying kerosene on weeds and floating debris covered with toad-bugs; much more effective than method shown in Plate XV.

PLATE XVII.—PIPING (1) AND SPRAYING OUTFIT ON FLOAT (2) FOR SPRAYING A LARGE BOG FROM ONE CANAL.
(Used primarily for cranberry diseases.)

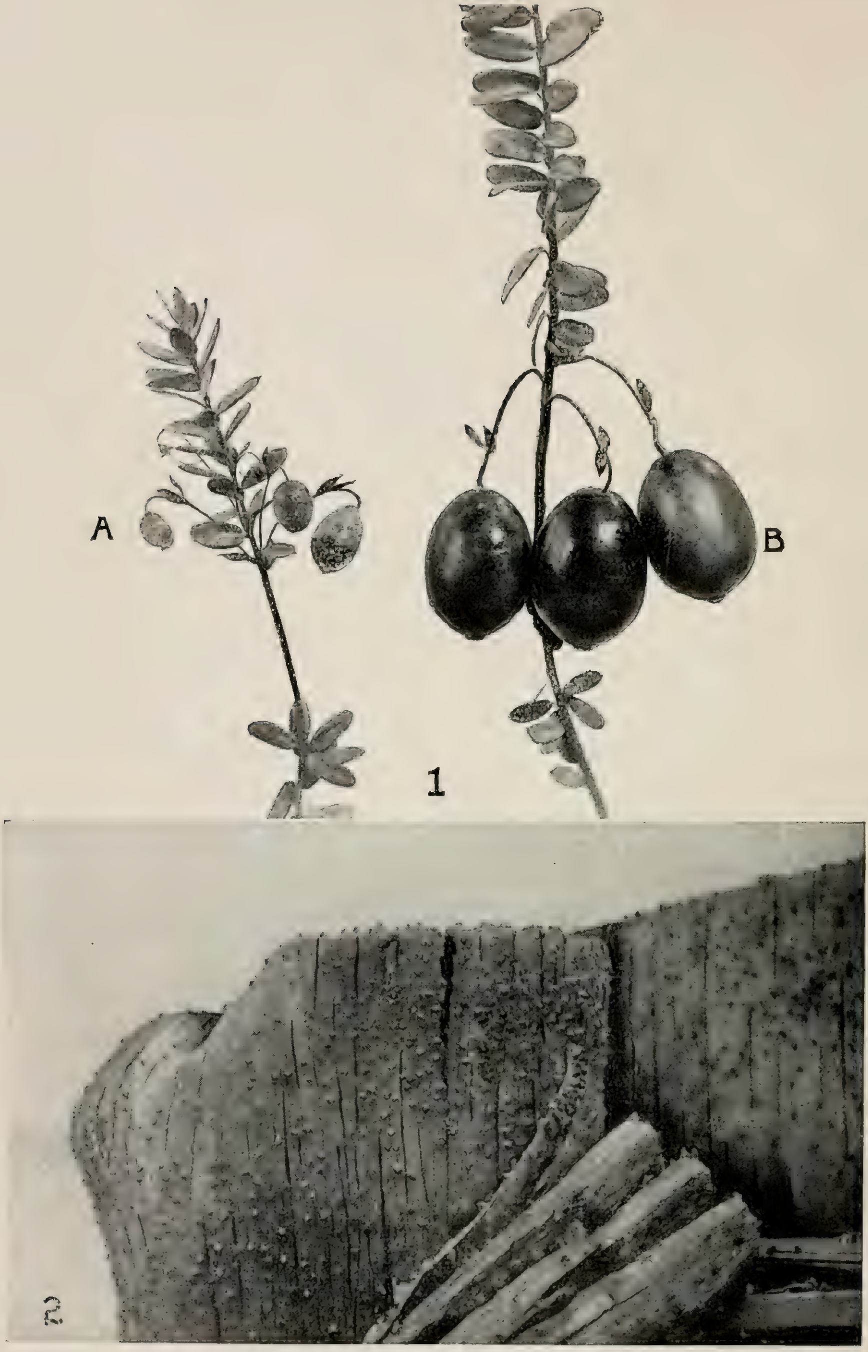


Plate XVIII.— Controlling Cranberry Toad-bug.

1, a, Plant injured by soap spray; b, uninjured plant; 2, toad-bugs that have come ashore from the flooded bog; on woodwork of flume.

when disturbed. After the third and fourth molts the insects are more active and are found more frequently on the new growth of vines.

Early in September some of the females reach maturity, when pairing begins. This function does not, as far as observed, interfere with the feeding of the females. In fact, it appears probable that the females feed until they commence to deposit eggs. In no stage of their development have they been observed, either in breeding cage or in the field, to feed on the leaves or leaf-petioles. Like the nymphs, the adults are shy creatures and when disturbed dodge to the opposite side of the branch on which they have been resting or feeding. When in their characteristic positions the long forelegs of the insects hold the anterior portions of their bodies well away from the branch on which they happen to be sitting, while their prominent eyes apparently enable them to see in all directions. Moreover, the posterior legs, which have spined tibiæ and tarsi, give a good anchorage and serve as powerful springing organs. The adults are able to jump at least a yard, but the distance they project themselves is not so remarkable as the velocity with which they are able to move under such circumstances. Because of the position in which they rest on a branch, the insects, when in the act of jumping, convey the impression that they are moving backward rather than forward.

EFFECT ON VINE AND FRUIT OF FEEDING OF TOAD-BUG.

The feeding of this pest on the vines of the cranberry produces apparently the same effect as that of the squash bug on vines and leaves of the squash; that is, the parts attacked wilt; but the evergreen leaves of the cranberry do not show wilting as plainly as the leaves of the squash. The first symptom of injury is the closing in, toward the branch, of the leaves on the new growth, while the leaves on the wood of the previous year's growth appear normal. (Plate XII, fig. 2, c and d.) The second stage of the injury is the change in color of the new growth, which takes a reddish tinge and finally a brown straw-color. Usually the work of the insects will first attract attention from a distance by a reddish tinge over the bog in July, similar to the fall-ripening effect of frost. Close examination of a plant will show a branch here and there on which all the leaves on the new growth are turning brown. This is followed by the dying of the branch, as if broken from the plant. Where the

insects feed only on the old wood, a condition that occurs frequently with the nymphs, the berries are dwarfed, as shown in Plate XII, fig. 2, d. Sometimes the berries shrivel or grow one-sided, but as a rule they remain miniature berries and ripen as such; but where bugs feed on the new branches, or a number of them on one old branch, the berries shrivel up and the branch dies. In cases where the insects feed on old wood, or wood of the previous year, all the new branches beyond the feeding point may produce dwarfed berries. It has been observed in the field that where one insect is feeding alone on new growth, this branch will wilt and change color. The plants usually start new buds below the point where the insects are feeding.

The amount of injury to the vines is considerable, as can readily be measured by the amount of fruit the affected plants produce. There is always a very characteristic difference between injured and uninjured portions of bogs, which could not be better illustrated than in the Brown bog at Calverton, L. I. In this planting there is a ten-foot drainage ditch which cuts a tract of Early Blacks into two parts. The portion south of the ditch has been infested for several years, while very few of the insects have reached the area north of the ditch. In the fall of 1911 the difference between these two tracts could be distinguished at a distance of a quarter of a mile. The affected side was brown and unhealthy in appearance, while on the opposite side of the ditch the vines were normally green and vigorous. The differences were noticeable in 1912, although, after the flooding operations in July, the affected portion threw out new growth and improved rapidly in appearance by fall.

HOST PLANTS.

The host plants listed by collectors of this species convey the impression that *atra* is a general feeder, but so far as observed by the writers this insect finds its subsistence only on the cranberry. Careful observations have failed to detect this species feeding on other marsh plants. After flooding of the bog the insects have been collected from weeds and willows on the sides of the marsh, but at no other season of the year have they been observed on these same plants.

ENEMIES.

The ladybird beetle (*Hippodamia 13-punctata*) and the soldier bug (*Coriscus inscriptus*) occur in abundance in bogs overrun with *atra*.

While we have not observed these attacking this pest, their presence under infested vines suggests that they prey upon the cranberry toad-bug. The spined soldier-bug, *Podisus spinosus*, occurs also in similar situations, but usually in much less abundance than the foregoing species. A number of undetermined ground and jumping spiders are generally quite common on the bogs, and these, we observed, were persistent enemies of the cranberry pest.

During 1913 a fungus disease was very conspicuous in the breeding cages and destroyed many specimens of the insects which were being used for breeding purposes. Evidences of this same disease were occasionally found in the field.

EXPERIMENTS WITH METHODS OF CONTROL.

TESTS OF FLOODING, 1912.

Bog No. 1.— This bog is located at Calverton, Long Island, on the Peconic River, and is owned by R. C. Brown. It contains about 25 acres and is divided by dams into five sections so arranged that they can be flooded separately by beginning at the upper section. As the importance of the cranberry toad-bug was not really understood until late in the season of 1912 it was decided not to attempt any spraying tests, but to try flooding in order to check further injuries by the insect. This experimental effort is of interest since it is contrary to general practice. While many of the cranberry growers flood their bogs before blossoming to combat such pests as the fruit and vine worms, the majority of them avoid flooding after the fruit is set because of the danger of "scalding" the berries. Selecting a day during a cloudy period, flooding was begun on July 20 over the entire section of the bog and the water allowed to remain for forty-eight hours to determine the effects on both the insects and the vines. It was soon discovered that the bugs would not remain under water or in the water if they could escape. They were driven to the tops of the vines, and as the water rose they would float off and climb the taller plants, generally weeds, or unsubmerged rubbish. A strong wind favored the flooding so that the bugs were all floated to one side of the bog, where they crawled to all available weeds, grass and willows in such numbers as to weigh the plants down. Judging from their activities, the insects were unaffected by this unusual experience. As they were driven ashore Mr. Brown sprayed them with pure kerosene, using a

compressed-air sprayer. He also tested the use of Vreeland's insecticide soap, using it at the rate of one part to six parts of water. This strength killed the bugs readily, but it did not penetrate the drift and rubbish as completely as did the kerosene.

Results on the insect.— Forty-eight hours after the water was drawn off an examination was made of the bog. The vines for the most part were free of the insects. In a few spots where the plants had not been completely submerged by the water many insects were observed, and a few specimens of the pest were also noticed along the margins of certain portions of the marsh, which indicated a re-invasion of the vines by bugs which had managed to escape from the treatment with kerosene because of protection by weeds and rubbish.

One week later young nymphs were found scattered in spots over the section of the bog that had been infested before treatment. These increased in number so much that by August 19 they were quite plentiful. However, it is of interest to note that one could readily distinguish between the insects on the bog before flooding and those that appeared later, since the older bugs were always larger than those that hatched after the treatment and were for the most part grouped along the margins of the bog or on the unsubmerged areas, while the others were scattered about the vines generally. From the better results secured by later flooding in 1913, and from the completed life-history studies, it is evident that this flooding was made too early in the season; so that not over three-quarters of the eggs were hatched when the bog was overflowed. After the flooding, the nymphs from the unhatched eggs, with those that escaped the oil through lack of thorough spraying when they floated ashore, reinfested the bog. The appearance of so many young nymphs after this flooding, joined with the fact that many eggs must have passed through the earlier flooding of June 13 and 14, proves that the eggs of this pest can stand quite an extended immersion in water.

Bog No. 2.— This bog, which is owned by S. H. Woodhull & Son, is located near Riverhead, Long Island, on Little River, and contains about 30 acres. It is so situated that the entire bog must be flooded together. Arrangements were made to flood as soon as the fruit was picked, the object being to determine as far as possible how late such a procedure could be carried out with advantage. It was also hoped that the late flooding would facilitate the studies

on the egg-laying habits of the pest, as the turning on of the water would compel the insects to live on the margins of the bog, where they would be more readily observed. The water was turned on October 2, 1912, and left on for 48 hours. Large numbers of the adults came ashore on drifting leaves and rubbish. The workmen hauled this rubbish up on the banks with rakes and later, as it dried, burned it. Part of the adults were dead as they floated ashore, but enough live ones came with them to blacken the weeds and grass on the margins. (No oil was applied to the rubbish on this marsh at the time of this flooding.)

TESTS OF FLOODING, 1913.

The experiments conducted during the preceding year demonstrated conclusively that the bugs could be driven from an infested bog by means of flooding. As both of the bogs previously described showed, early in July, 1913, that they were still infested, it was decided to flood both. Aside from the desirability of protecting the cranberries from the insects, it was also felt that more information was needed as to the most efficient use of the water as a means of control, as well as the most effective methods of disposing of the insects as they floated ashore.

Bog No. 2.— Since Bog No. 2 began growth a trifle earlier than No. 1 and was also through blossoming sooner, it was the first to receive attention. After waiting for a cloudy period in order to avoid scalding of the fruit, and a favorable wind, the water was turned on in this bog at 6 p. m. of July 23. At noon the next day part of the vines on one side were not entirely submerged, and many sedges, " three square," and weeds on part of the bog were not covered. (Plate XIII, fig. 2.) Fortunately the direction from which the wind blew was such that the insects from the worst infested sections were not carried to the portions not entirely submerged. The water was left on all day the 24th. Three men with knapsack and compressed-air sprayers worked a good share of the day spraying the weeds, grass and margins of the water with pure kerosene, kerosene emulsion (one part to seven of water), and homemade fish-oil soap (one part to seven parts water). The men also waded out and sprayed the bugs that were found collecting on sedges and weeds not submerged. All three substances used killed large numbers of the bugs, but for penetrating the rubbish that floated ashore and for spread-

ing over the surface of the water, kerosene proved the best. Many millions of the bugs drifted ashore and were killed by the treatment.

The water was drained from the bog during the night of July 24, beginning at 8:30 p. m., and by morning was back in the ditches. The men began raking the drift rubbish from the vines on the margin of the bog where the receding waters had left it, after which the rubbish was sprayed again with kerosene. On the next day it was found that a few living bugs were coming from the masses of rubbish and the thick grass and were working back to the bog. A knapsack was rigged with a ten-foot rod and "Mistry Jr." nozzle for spraying kerosene and burning it at same time. (Plate XIV, fig. 1.) With this outfit the bugs contained in the thick grass and wet rubbish were destroyed.

The items of expense in disposing of the insects along the margins of this 30-acre bog are as follows: 65 gals. of kerosene, $7.50; labor, 3 men for one day, $5.25. This makes a total cost of $12.75 for the final spraying and burning operations.

Results on insects and plants.— On August 6 the bog was carefully examined to note the effects of the different operations on the numbers of the bugs. All portions entirely covered with water were generally completely free of the pest. As in former experiments, varying numbers of the insects could be found near unsubmerged weeds, grass, sedges and vines. Only a few nymphs of the first instar were detected, indicating that but few eggs were not hatched at the time of flooding or that small numbers of the insect in the very immature stages may withstand immersion. There were no indications of scalding of fruit as a result of the flooding.

Bog No. 1.— Profiting from the experience during the previous year on this bog and from the experimental operations just completed on Bog No. 2, as described above, an effort was made to have all the sections of the bog to be flooded clean at the time of overflowing. Besides removing all weeds and sedges from the beds, the margins of the ditches as well as those of the bog were mowed. The effects of these operations in facilitating the submersion of the marsh is shown in Plate XIII, fig. 1.

On August 1, at 5 p. m. during a rain storm, the water was turned on, and by 6 a. m. the next day the flooded sections of the bog were well covered. Unfortunately the wind dropped and proved hardly strong enough to compel the bugs to drift ashore. As the

prospects were slight that the remainder of the floating insects would be driven to the land, spraying and burning operations were undertaken. The burning torch-spray was used with great advantage on the grasses and weeds, while the oil applied as a spray proved a most efficient treatment for the insects floating on the water. (Plates XV and XVI.) Besides spraying the surface of the water within reach of the shore line, applications of oil were made to cover floating insects and debris of all sorts which passed through a flume as the water was drawn off. (Plate XVI.) In these spraying operations 65 gallons of kerosene were used, while two men were employed for a half day, making a total cost of eight dollars for this operation.

Results on insects and plants.— An examination of this bog on August 9 showed no trace whatever of the bugs on the flooded section. It should be noted, however, in the flooding of an upper section some insects may find their way to a lower section, probably by jumping over the intervening dam, and in this experiment a few individuals managed to escape by such means. The submersion of the vines did not produce any scalding of the fruit.

TESTS WITH VARIOUS INSECTICIDES, 1913.

As Bog No. 2 was flooded very late in the season of 1912, a close watch was kept during the following summer to determine if the insects would appear in injurious numbers. In July there were indications that the bugs were very plentiful and that they might do considerable damage by the time flooding could be safely attempted, with assurance of satisfactory results. It therefore appeared desirable to postpone the turning on of the water, and in the meantime to resort to other methods to keep the insects under control, until all of their eggs were hatched. Spraying with contact insecticides seemed to be the most promising procedure, and, moreover, tests along this line were desirable, since it was important to know if spraying would be, in any way, of more advantage than flooding, and, if so, what substances were best adapted for the treatment of cranberries. There are some bogs which are known as " dry " bogs where flooding is impracticable, and in the case of such a pest as the cranberry toad-bug spraying would probably have to be relied on as the chief means of defence. To this end the following tests were made.

Bog No. 1.— On July 4, Mr. Brown tested spraying with resin-

potash soap, 1 pound to 6 gallons of water, on plants that were in full bloom, and other vines that were well infested with the insects.

Results on insects and plants.—As far as could be determined very little if any of the spray reached the young nymphs and little or no protection was afforded the vines. An examination on July 27 showed that the set of fruit had been reduced at least 75 per ct. as the result of injury to the blossoms.

Bog No. 2.— On this bog the following insecticides were tested: Vreeland's insecticide soap, Good's resin potash soap, homemade fish-oil soap[10] and "Black Leaf 40." The first application was made July 9. The spraying plats were arranged as shown in Chart 1.

canal

3 rods	Fish-oil Soap 1 to 7 1 bbl. used twice sprayed	Insecticide Soap 1 to 5 1 bbl. used	Resin Potash Soap 1 to 5 1 bbl. used	Black Leaf 40 1 to 800 1 bbl. used	B.L.40 1 to 400 1 bbl. used
	3 rods	6 rods	6 rods	5 rods	3 rods

CHART 1.

These materials were applied with a cluster of three "Mistry Jr." nozzles at a pressure on pump of 180 lbs., the engine and pump being mounted on a float in the canal. (Plate VII, fig. 2.) By examining the vines as fast as sprayed, it was found that many of the nymphs had been disturbed and were working up towards the tops of the vines. Hence, on the plat where homemade fish-oil soap was used, a test of respraying was made as soon as it had been sprayed over once.

Results on insects.— Two hours after spraying, all the plats were examined again, and no dead nymphs of the toad-bug were found except where the double spraying with the fish-oil soap was given.

On July 11, a second attempt was made to kill the cranberry toad-bug by spraying. In this effort a different section of the bog was used, which is devoted to the Centennial variety. As the bog is laid with galvanized piping, for spraying all portions from the canal, this equipment was used for the treatment of the experimental plats. (Plate XVII, fig. 1.)

[10] N. Y. Agr. Exp. Sta. Bul. No. 257, p. 434.

The following chart shows the size and arrangement of the different plats and methods of treatment.

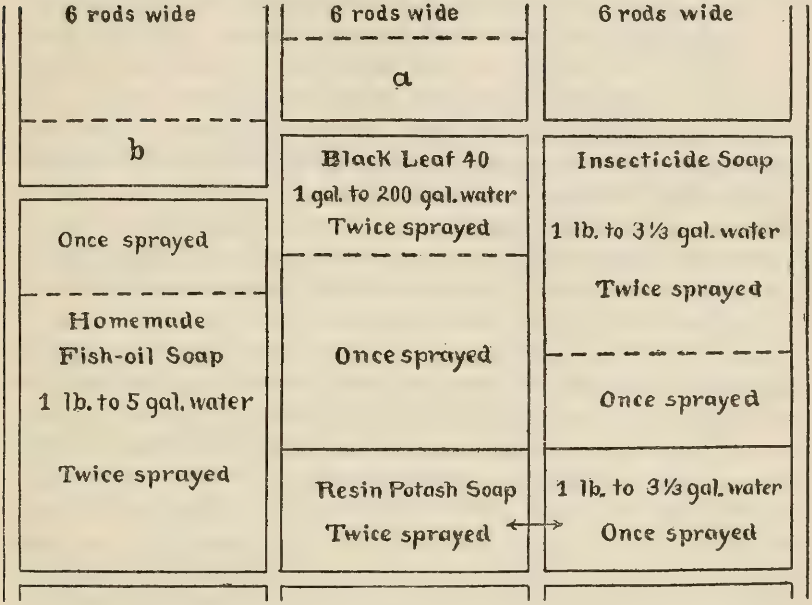


CHART 2.
(Parallel lines, except those at right, indicate ditches.)

Results.—One hour after spraying, a rough estimate of the effects of the different treatments was made, which was based on the number of insects moving as compared with those dead on the ground. In general, where the vines were thin and scattered, the soap solutions killed the majority of the nymphs, but on the heavy vines the applications were quite ineffective. The estimated percentages of insects destroyed by the different mixtures are as follows: By two applications of insecticide soap, resin-potash soap and homemade fish-oil soap, 70 per ct. of the insects were killed, and by one application 20 per ct.; by two applications of "Black Leaf 40" 1 per ct. were killed, and by one application, none were killed.

Since there was no apparent injury to vine or fruit from the treatment of July 11, and as there was still some soap stock on hand and the insects were very numerous, it was thought best to make a third series of tests. Accordingly, on July 15 all that portion of the bog sprayed July 11 was resprayed as follows:

The middle section and the small plat marked "a" (Chart 2) were sprayed with homemade fish-oil soap, 1 lb. to 5 gallons of water, while the remainder of the plats and the section marked "b" were sprayed with insecticide soap, 1 lb. to $3\frac{1}{3}$ gallons of water. All plats were twice sprayed as follows: A strip about 12 ft. wide was sprayed across each bed, then resprayed immediately before starting on another strip, and so on until each section was sprayed. From the experiments that were conducted, it was estimated that on an average approximately 200 gallons of mixture would spray one acre twice. On this basis, without including labor, "Black Leaf 40," used 1 gallon to 200 gallons of water, would cost $12.00; insecticide soap, 1 lb. to $3\frac{1}{3}$ gallons water, would cost $5.40; resin-potash soap, 1 lb. to $3\frac{1}{3}$ gallons water, would cost $2.00.

Results on insects and plants.— Without resorting to an actual count of the numbers of dead and living insects, it appeared that this method of spraying did not give as marked results as the one followed on July 11 where a longer interval of time was allowed between each application. The explanation for this marked difference in results is not clear. Apparently the effect of the first application was to force a good many of the insects into the tops of the vines, where they would be more quickly dried by the sun and the air. If sufficient time was allowed, many of the insects would occupy positions which would render them quite exposed to the second treatment. Then, moreover, it proved a difficult matter to do thorough spraying. In some instances it was almost impossible to reach all of the young nymphs feeding on the undersides of the branches, as the heavy growth interfered with the spray, preventing complete wetting of the foliage and wood.

Early in September, it was discovered that wherever the soap solutions were used stronger than 1 lb. to 7 gallons of water, not over one-third of the berries were perfect. Of the affected berries very few were shriveled or showed injury to one side. In most cases they were dwarfed, as shown in Plate XVIII, fig. 1, a; b is normal fruit collected one foot from the sprayed section. Another characteristic of the soap-treated sections appeared later in the plants themselves. As the vines took on a natural reddish tinge late in the fall, the sprayed sections remained dark green as if recently given an application of nitrate of soda. It appeared that the vines bearing stunted fruit had put all their energy into a new growth of wood instead of fruit.

This injury was more marked where insecticide soap was used, apparently due to the fact that more of it would dissolve in a given amount of water, whereas with homemade soap, used 1 to 5, some of the material always remained undissolved in cold water.

CONCLUSIONS AS TO METHODS OF CONTROL.

The experiments herein described indicate plainly that of the two methods of control — flooding and spraying — the former is to be preferred if submersion of the bog is possible. Spraying the plants proved in the main less satisfactory as measured by the numbers of the bugs destroyed and the injury to the plants. Damage to cranberries may apparently arise from the use of too strong mixtures of soap, by too liberal applications of the spraying materials or by early treatments when the vines are in blossom. Further experiments with contact insecticides are desirable in order to determine conclusively the practicability of combating this pest by the application of spraying mixtures.

DIRECTIONS FOR CONTROLLING THE CRANBERRY TOAD-BUG.

From the knowledge of the life history and habits which has been so far ascertained, flooding should be deferred until from the first to the middle of August for sections in the same latitude as New York City. If submersion is practiced earlier than August 1 some nymphs may make their appearance after the water is removed, while if postponed until after August 15 eggs may be deposited in the bog which would permit reinfestation of the vines in the following summer. In selecting a date, some allowance should also be made for seasonal conditions. On the basis of the experiments previously described a cloudy period should be selected for flooding. The water should be turned on in the evening so that the bog will be completely covered by the next morning. Advantage should be taken of a favorable wind in order that the bugs may be floated ashore. Grass and weeds should be removed from the bog before flooding, while similar growth about the margins of the marsh should be mowed. Kerosene oil should be applied as a spray to all insects and debris floating on the surface of the water. Thick grass, weeds and drift on the shore should be burned by means of the burning torch-spray. If these precautions are carefully followed practically all of the insects can

be killed. Such complete extermination is not often met with in the control of an insect pest.

In flooding a bog to destroy this pest a word of caution is urged. A study of the life cycle of the bug and of its different forms and habits indicates that only the long-winged forms migrate under natural conditions; and it appears more than probable that even this form does not migrate very long distances. Carelessness in flooding during the summer would undoubtedly distribute them faster than any other method. It seems very doubtful if they are ever distributed by the transportation of the vines; because, first, the eggs rarely, if ever, remain on the vines; and second, the vines for transplanting are usually taken before the eggs hatch.

On what are known as " dry " bogs, where no method but spraying can be adopted, the following suggestions are offered: First, in cases where the vines are heavy and contain much old wood, mow the vines off at the usual season for cutting. Second, between August 1 and 15 spray thoroughly with a soap solution made with any of the three soaps — insecticide soap, resin-potash soap, or homemade fish-oil soap — 1 pound to seven gallons of water, applying at least 200 gallons of solution to the acre at each application and making two applications. By this method there would be no fruit to be injured with the soap solution, as cutting eliminates a crop of fruit for one year. In plantings where vines are very thin the cutting might be dispensed with, but would probably be a good cultural method even in such cases.

ACKNOWLEDGMENTS.

The senior author wishes to thank Messrs. Brown and Woodhull for their assistance in furnishing materials, apparatus and men free of charge for carrying out the tests made; for taking all the risk of damage to the crop by treatments tested; and for general assistance which has helped to round out this report.

THE CABBAGE MAGGOT IN RELATION TO THE GROWING OF EARLY CABBAGE.*

W. J. SCHOENE.

SUMMARY.

The cabbage maggot is the principal handicap in the production of early cabbage and cauliflower. The insect is present in most communities where early cabbage is grown and occasionally causes extensive damage to this crop.

Of the insecticides that are employed to destroy maggots about the roots of the plants, carbolic-acid emulsion has generally been regarded as the most efficient. Tests with the emulsion at recommended strengths have demonstrated that it will prevent the hatching of the eggs and is fatal to the younger stages of the larvae. It may, however, cause injury to young seedlings and is not a safe remedy for the treatment of plants recently set in the field.

The value of tar pads, or hexagonal tar-paper collars, for the purpose of preventing the adult of the cabbage maggot from placing eggs about the stems of the plants has been previously demonstrated, but, in spite of its effectiveness, this method of protecting cabbage has not been generally adopted by truck growers. The tests herein described show that tar pads will protect early cabbage from the pest at a cost of about $1.40 per thousand plants. Truck growers who are subject to losses by the cabbage maggot are urged to test the tar pads experimentally as a basis for more extensive operations against this pest.

INTRODUCTION.

The cabbage maggot (*Pegomya brassicæ* Bouché) annually occasions extensive losses to vegetable-gardeners and cabbage-growers. Its importance in the production of late cabbage and methods for preventing its destructiveness in seedbeds have been discussed in two bulletins (301 and 334) of this Station. The purpose of this publication is to discuss its injurious work in relation to the growing of early cabbage, and to point out, on the basis of various experimental operations, the merits and uses of carbolic-acid emulsion and tar pads for the protection of plantings.

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* Reprint of Bulletin No. 382, April; for Popular Edition see p. 926.

Chart 3.— Relation of Time for Transplanting and Growing Early Cabbage to Dates of Appearance of the Cabbage Maggot in Its Various Stages.

Time of transplanting and growth period of early cabbage.	Date.	Time of appearance of cabbage maggot.
	April 29	
	" 30	
	May 1	
	" 2	
	" 3	
	" 4	
	" 5	
	" 6	
	" 7	
	" 8	
Time of transplanting early cabbage....	" 9	
	" 10	
	" 11	
	" 12	
	" 13	
	" 14	
	" 15	Cabbage-maggot flies very numerous.
	" 16	
	" 17	
	" 18	
	" 19	
	" 20	
	" 21	
	" 22	
	" 23	
	" 24	
	" 25	
	" 26	
	" 27	Eggs of cabbage flies in greatest numbers.
	" 28	
	" 29	
	" 30	
	" 31	
	June 1	
	" 2	
	" 3	
Growth period of early cabbage......	" 4	
	" 5	
	" 6	
	" 7	
	" 8	
	" 9	
	" 10	
	" 11	
	" 12	
	" 13	
	" 14	Maggots full grown and period of greatest injury to early cabbage.
	" 15	
	" 16	
	" 17	
	" 18	
	" 19	
	" 20	
	" 21	
	" 22	
	" 23	
	" 24	
	" 25	
	" 26	
	" 27	
	" 28	
	" 29	
	" 30	
	July 1	
	" 2	
	" 3	
	" 4	
Time of cutting......................	" 5	
	" 6	
	" 7	
	" 8	

LIFE HISTORY OF CABBAGE MAGGOT WITH REFERENCE TO GROWTH OF EARLY CABBAGE.

In the latitude of Geneva the adults of the cabbage maggot appear about May 15 during normal seasons, and the eggs of this species usually occur in large numbers about the roots of cabbage and other cruciferous plants from May 20 to June 5. The work of the maggot is most conspicuous during the last two weeks in June. The time of appearance of the adults and the period of egg laying are hastened by warm weather during April and May. In order to secure the highest prices early cabbage should ordinarily be ready for market in July. For this reason it is necessary to transplant the seedlings from the greenhouse or cold frame in the latter part of April or early in May. During the three or four weeks following the planting in the field, cabbages are most susceptible to injury by this insect. The accompanying chart shows clearly the life history of the pest with reference to the growing of early cabbage. It should be noted that the maggots are most numerous when the plants are small, and therefore most vulnerable to attack.

STATION EXPERIMENTS IN PROTECTING EARLY CABBAGE.

Many methods have been proposed for the protection of early cabbage from the cabbage maggot. In a series of preliminary tests carbolic-acid emulsion and tar pads proved to be the most effective of the various protective and remedial measures commonly recommended for the control of this pest. In order to ascertain their applicability to the needs of market gardeners and truckers in this State, both of these have been tested in the laboratory and in a number of cooperative field experiments which are briefly described under the headings (1) *Tests with Carbolic Acid Emulsion* and (2) *Tests with Tar Pads.*

TESTS WITH CARBOLIC-ACID EMULSION.

References to use of carbolic acid for the control of root maggots.— An emulsion of carbolic acid of 0.1 per ct. strength was used by Cook [1] as a remedy for the cabbage maggot in 1881. He reports that frequent applications with this diluted material protected radishes

[1] *Can. Ent.* **13:** 189.

from maggot attack, without injury to the plants. Again, in 1886, Cook [2] tested a stronger solution that contained .44 per ct. of the acid. The insecticidal properties of carbolic acid at this dilution were evident, but the plants were injured wherever it was used. In 1887 Fletcher [3] reports that he successfully protected a crop of radishes from root maggots with the strength of emulsion first used by Cook. Following this experience Fletcher [4] has recommended this mixture many times in his reports. Slingerland [5] employed an emulsion in his tests that contained 0.32 per ct. of carbolic acid. This gave some protection against maggots and did not injure the plants in any of his tests. He sums up his work by saying "we believe it is the most successful and most practical method of treating radishes, turnips or onions yet devised."

The earlier writers regarded the carbolic acid as a preventive and not a remedy. Slingerland believed, on the contrary, that it was a strong larvicide, and gave a full discussion of the action of the material in his tests. Washburn [6] records, in 1906, some field tests in which he treated cabbage with an emulsion containing 0.37 per ct. of carbolic acid. There was very little injury to this field by maggots, so there was no opportunity to observe the effect of the material as a larvicide; but the checks were perceptibly better than the plants treated with the emulsion, and Washburn states that the comparatively poor showing of the treated plants suggests that the carbolic acid may have had an unfavorable effect. In connection with another test he says that the material works injury if applied to very young plants. In 1907 Smith [7] mentions carbolic acid as one of the most effective of all the destructive agents for this pest. He says that it is necessary to apply it early and to get the material down to the roots. In 1908 Washburn [8] reports another test which is similar to his above-mentioned report, in that the checks were better than the treated plants. Collinge [9] of England

[2] Mich. Bd. Agr. Rpt. 1886, p. XXXIX.
[3] Can. Exptl. Farms Rept. for 1887, p. 22.
[4] Central Exptl. Farm (Can.) Bul. 11, pp. 14 and 29. 1891.
Can. Exptl. Farms, Rpt. 1898, p. 195.
U. S. Dept. Agr., Ent., Bul. 46, p. 85. 1904.
[5] N. Y. Cornell Exp. Sta. Bul. 78, p. 529 and 553.
[6] Minn. Exp. Sta. Bul. 100, p. 11–12. 1906.
[7] N. J. Exp. Sta. Bul. 200, p. 22. 1907.
[8] Minn. Exp. Sta. Bul. 112, p. 201. 1908.
[9] Collinge, W. E. Letter Feb. 17, 1913.

states that the large growers in that country will not use tarred disks, but the liquid soil insecticides have been used with good results.

The above discussion deals only with some of the references to carbolic-acid emulsion that occur in the literature of the cabbage maggot. These references show, however, that the material has been regarded by entomologists as a strong larvicide; that it will injure plant growth when not sufficiently diluted, and that it may have some effect as a repellent. The experiments recorded by Washburn suggest that, even when used at a dilution of 0.37 per ct., the carbolic acid may have a retarding effect upon the growth of the cabbage.

Laboratory tests to determine the effects of carbolic-acid emulsion on the eggs of the cabbage maggot: Test No. 1.— Three lots of eggs were placed in clay saucers and immersed for five minutes in carbolic-acid emulsion containing $1\frac{1}{3}$ per ct., 0.66 per ct. and 0.33 per ct. crude acid, while other eggs were left untreated as a check. Apparently the carbolic acid had no effect on the time of hatching or the percentage of eggs hatched.

Test No. 2.— In this experiment eggs were placed between moist filter papers which were then slightly covered with sandy soil, similar to that occurring in fields in which early cabbage is grown. The liquid insecticide was then applied to the soil as if the eggs were about cabbage plants. The results were as follows:

1.33 per ct. acid	15 eggs	0 hatched.	
.66 per ct. acid	15 eggs	5 hatched.	10 not hatched.
.33 per ct. acid	15 eggs	0 hatched.	
Check	15 eggs	15 hatched.	

Test No 3.— This is a repetition of Test No. 2. The results are as follows:

1.33 per ct. acid	10 eggs	0 hatched.
.66 per ct. acid	10 eggs	0 hatched.
.44 per ct. acid	10 eggs	3 hatched and these larvæ died near egg shells.
.33 per ct. acid	10 eggs	0 hatched.
Check	10 eggs	8 hatched.

Results.— Attention is called to the results of tests Nos. 2 and 3 in which eggs remained in contact with the soil that had been wet with the liquid insecticide, until the surplus liquid evaporated, as would occur when plants are treated in the field. In these tests the carbolic acid functioned as an ovicide, and mixtures as weak

as 0.33 per ct. acid were fatal to the eggs. The eggs that failed to hatch in these tests with carbolic acid became pale brown in color, which discoloration occurred about the time the checks hatched.

Laboratory tests to determine the effects of carbolic-acid emulsion on larvæ: Test No. 1.— To ascertain the larvicidal value of carbolic acid, tests were made as follows: Larvæ were immersed for one hour in the emulsion at the strength indicated in the accompanying table and then placed on moist sand for later examination. The insects used in these tests were classified according to size. The "small" larvæ were in the second instar, the "medium" sized larvæ were recently molted individuals of the third instar, while the "large" larvæ were mature individuals of the third instar. The results of this series of tests are shown in Table I:

TABLE I.— EFFECT OF DIFFERENT STRENGTHS OF CARBOLIC ACID ON MAGGOTS.

Strength of emulsion.	Number of larvæ in test.	Size of larvæ.	Number killed.	Number alive after treatment.
0.17 per ct. carbolic acid	5	medium	0	5
	5	large	0	5
0.22 per ct. carbolic acid	5	small	4	1
	5	medium	3	2
	5	large	0	5
0.33 per ct. carbolic acid	5	small	5	0
	5	medium	3	2
	5	large	1	4
0.33 per ct. carbolic acid	5	small	5	0
	5	medium	5	0
	5	large	0	5

Test No. 2.— To determine the effects of carbolic acid on mature larvæ of the third instar under field conditions, the following experiment was made. The larvæ were placed in a slight depression in a rather dry soil for treatment, and after the mixture had been applied at strengths indicated in the table they were then slightly covered with earth. The effects of the treatment are shown in Table II.

Table II.— Effect of Carbolic Acid on Maggots Under Soil Conditions.

Strengths of emulsions in carbolic acid.	Number of larvæ in test.	Number killed.	Number alive after treatment.
0.22 per ct.	5	0	5
0.26 per ct.	5	1	4
0.33 per ct.	5	2	3

Results of tests with carbolic-acid emulsion on larvæ.— These tests show that immersion in carbolic-acid emulsion containing 0.33 per ct. is fatal to the larvæ of the second instar, and that the smaller individuals of the third instar are to a large degree susceptible to treatment, while the large maggots of this same stage are immune.

Field experiments with carbolic-acid emulsion.— During the spring of 1906 a cabbage seed-bed was treated with carbolic-acid emulsion by Mr. L. A. Page of Seneca Castle, in cooperation with the Station. The soil about the roots was thoroughly saturated by gently pumping the mixture through a spray hose with the nozzle removed. The maggots were numerous about the roots of the plants and had caused serious injury before they were discovered. Apparently the work of the insects was not checked by the emulsion, for the seed-bed was so completely destroyed that no plants were available for transplanting. A similar experiment with this mixture was performed in 1908 on the same farm. The application was made to a seed-bed in anticipation of an attack by the insect. The maggots were few in number, and following the application no differences were observed in the treated and untreated plats. It should be noted that the emulsion was not harmful to the young seedlings which at the time of treatment were from five to seven inches high. In another experiment in an adjoining seed-bed during the same season the emulsion proved very destructive when applied to young seedlings one to two inches high.

During 1913 the emulsion was used at a dilution of 0.37 per ct. carbolic acid in two commercial plantings of early cabbage. The soil in one field was a heavy clay while in the other it was a light sand. In both of the tests the emulsion caused serious injury to

seedlings that had recently been transplanted in the field, as approximately 50 per ct. died, and the remaining plants were much retarded as a result of the treatment. Plants that were well established and that had made appreciable growth before the application were not harmed. Injuries as a result of the treatment of carbolic acid appeared to be confined to the outer cortex of the root and were much more extensive with some plants than with others. Plants that were only slightly injured by the emulsion recovered from the effects of the treatment but they failed to produce heads.

Conclusions from tests with carbolic acid.— Carbolic-acid emulsion, when diluted to contain 0.33 per ct. crude acid prevents the eggs of the cabbage maggot from hatching; also the emulsion at this strength is fatal to the larvæ of the first and second instars and to some of the recently molted individuals of the third instar. The mature larvæ of the third instar are not susceptible to this treatment. As shown in these tests, cabbage seedlings that have been recently transplanted from the cold frame to the field are liable to injury by the carbolic acid, even at the dilute strengths usually recommended, while similar plants, when once the root system has become established, have not been affected by the treatment.

TESTS WITH TAR PADS.

References to use of tar pads for production of early cabbage.— The idea of protecting early cabbage plants by the use of paper collars seems to have originated with W. W. Tracy of Detroit, Mich., who tried manila paper without success. Goff of the Wisconsin Station placed tarred disks on an experimental basis by testing different types of paper for this purpose and devising a tool for cutting the hexagonal disks. He also tried grafting wax to fasten the papers to the stems of the plants. In the preliminary tests the tarred paper disks, without grafting wax, gave efficient protection to the seedlings, so samples of these were sent to gardeners to be tried in commercial plantings. Smith Brothers of Green Bay, Wisconsin, employed the disks for the protection of one or more acres of plants for at least three seasons. The results of this cooperative test, which were very favorable to the paper disk, were reported in detail by Goff.[10] This test was reviewed by Slingerland[11] who also pub-

[10] Wis. Exp. Sta. 8th Ann. Rept. p. 169–173. 1891.
10th Ann. Rept. p. 259–261. 1893.

[11] N. Y. Cornell Exp. Sta. Bul. 78, p. 521–527. 1894.

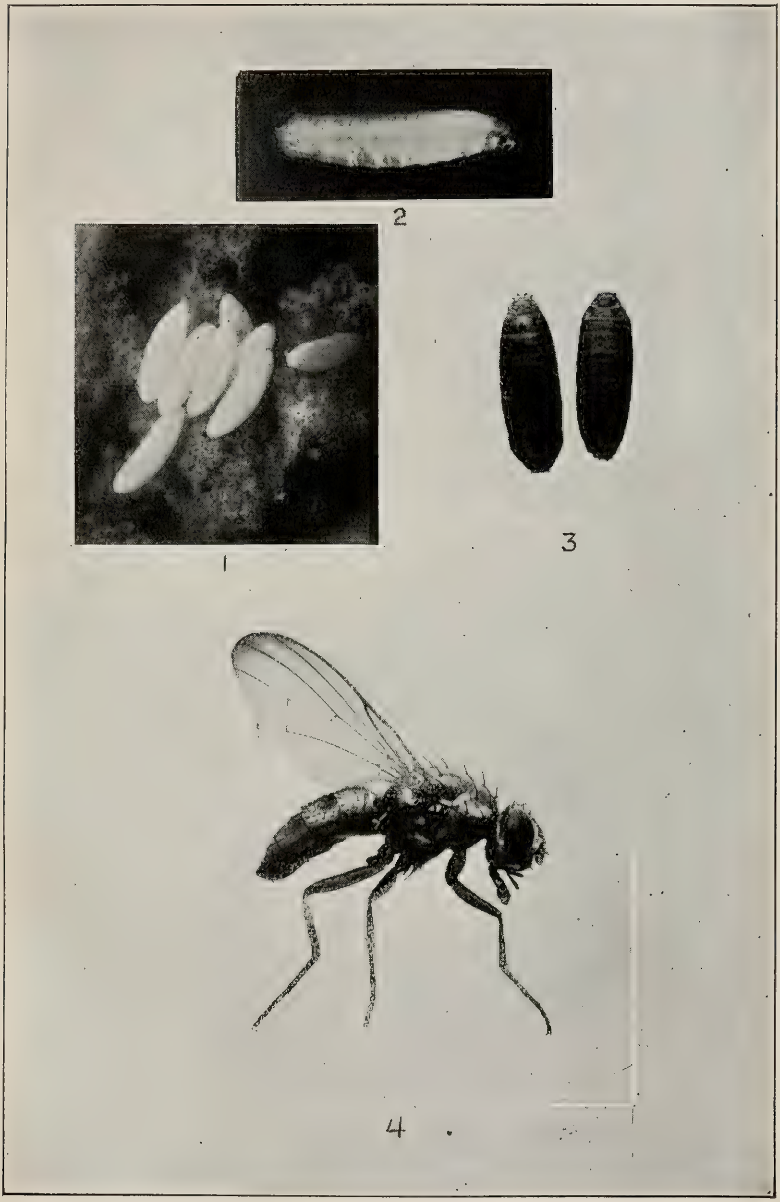

Plate XIX.—Life Stages of Cabbage Maggot:
1, Eggs; 2, larva; 3, puparia; 4, adult female.

Plate XX. — Tar-Pad Experiment on Baker Farm, 1913.
(Photographed June 5.)

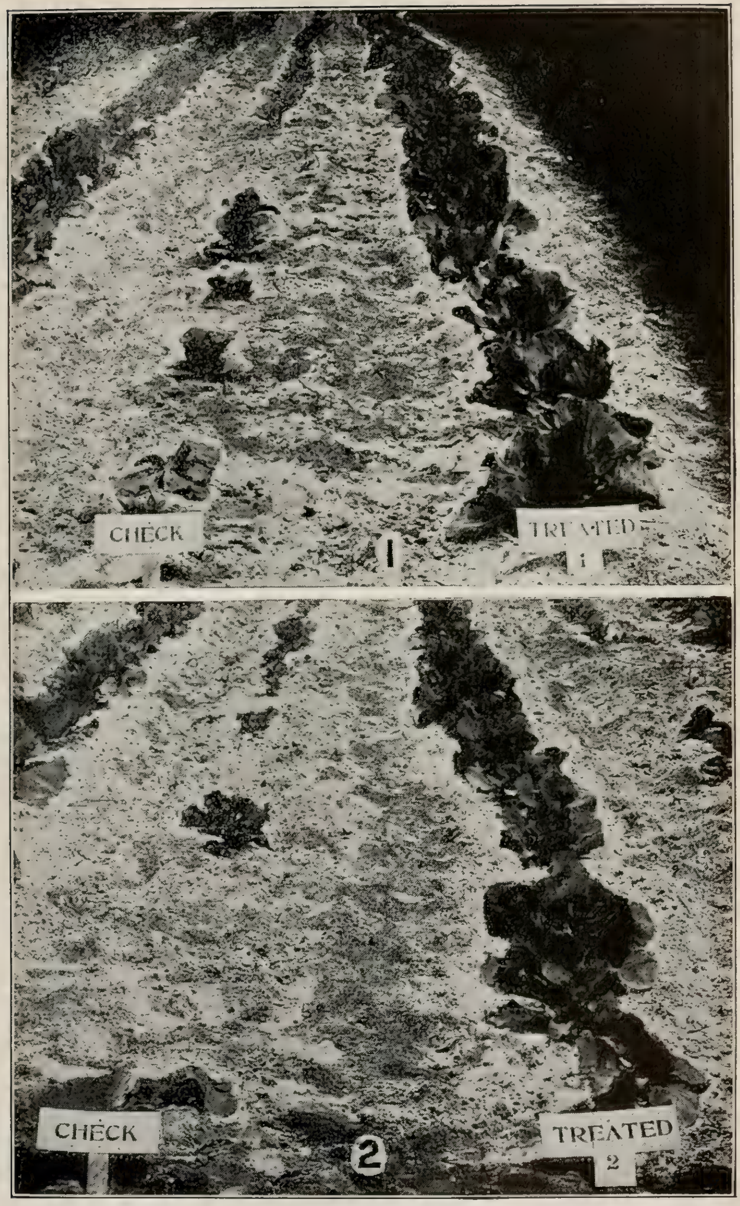

Plate XXI.— Experiment with Tar Pads on Baker Farm: 1, Row 1 and checks; 2, Row 2 and checks.

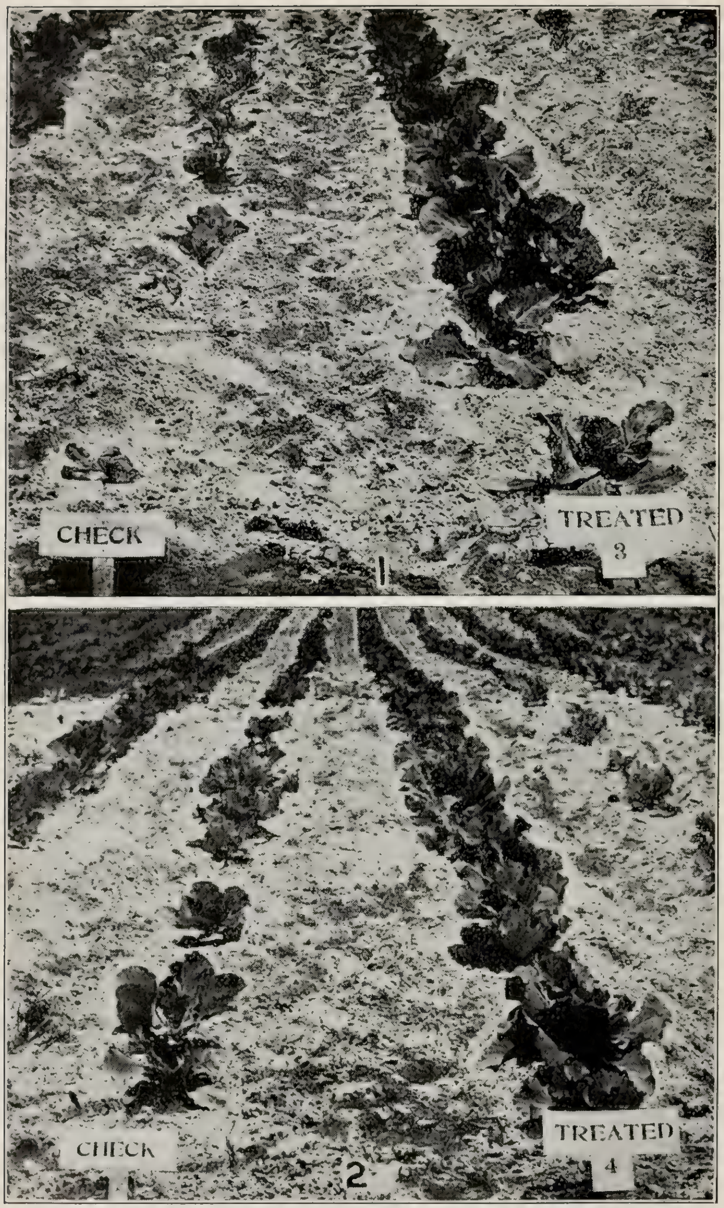

PLATE XXII.—EXPERIMENT WITH TAR PADS ON BAKER FARM: 1, Row 3 and checks; 2, Row 4 and checks.

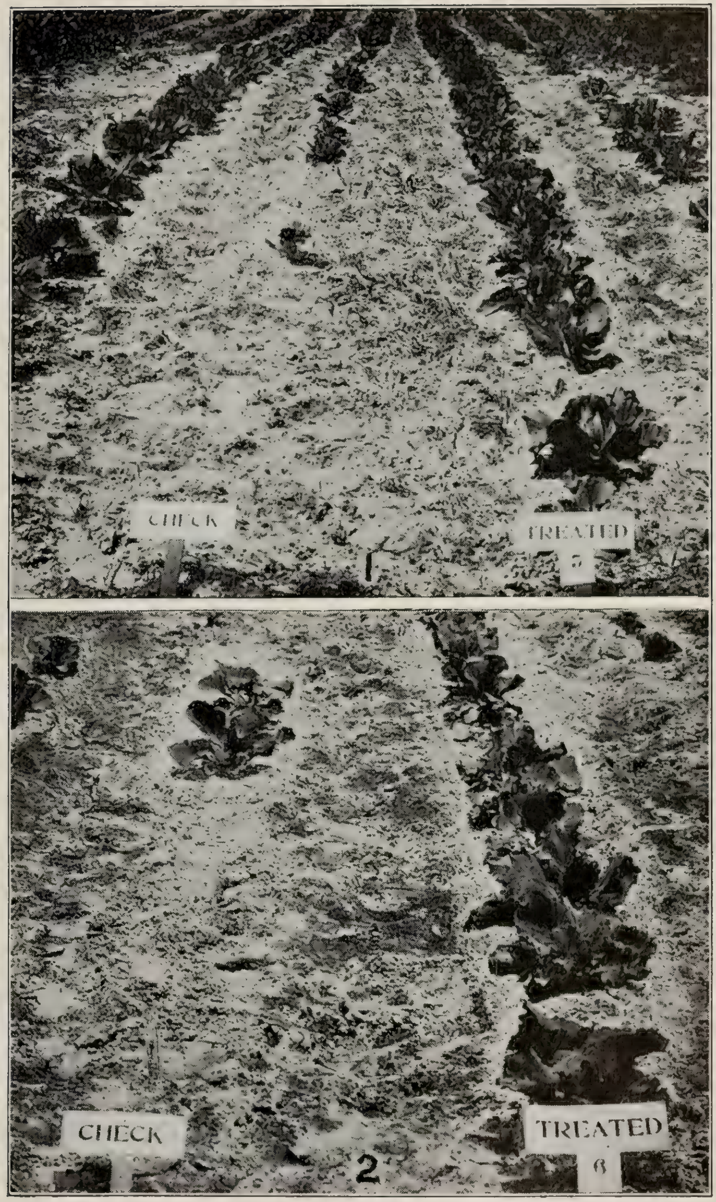

PLATE XXIII.— EXPERIMENT WITH TAR PADS ON BAKER FARM:
1, Row 5 and checks; 2, Row 6 and checks.

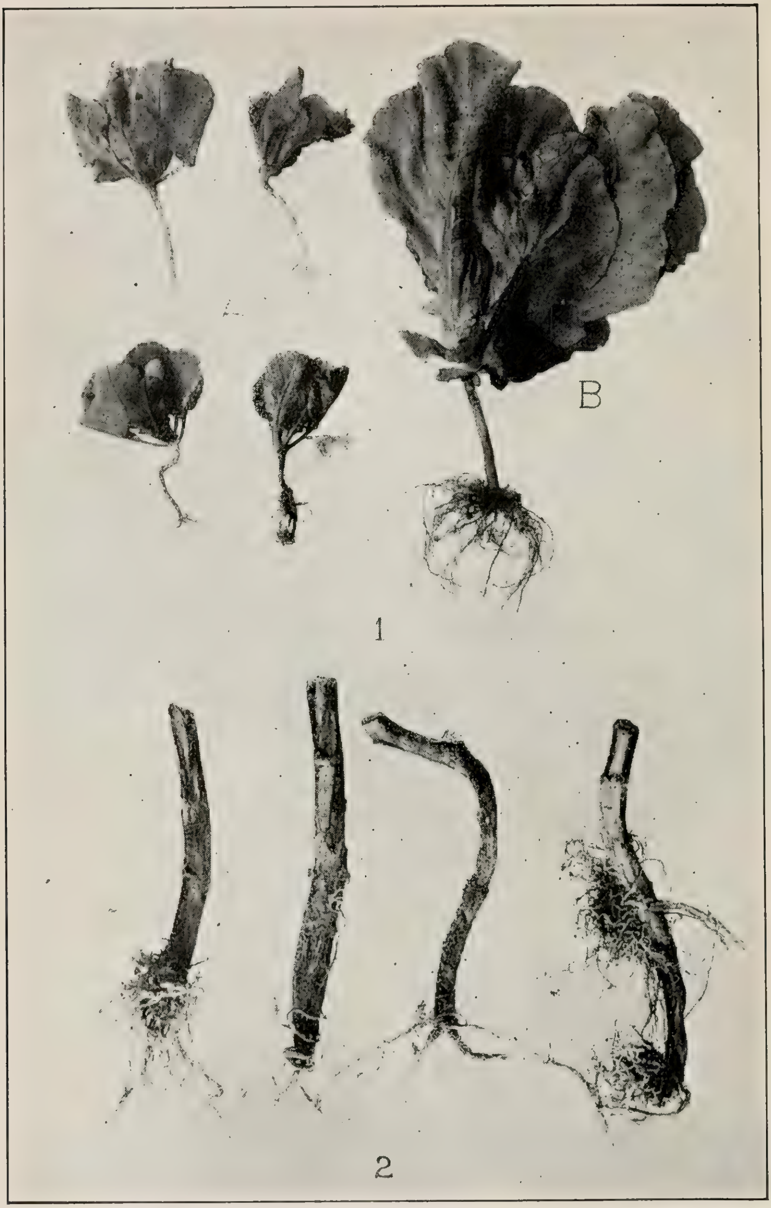

Plate XXIV.—Stunting Effect of Cabbage-Maggot Work:
1, a, Plants injured by maggots; 1, b, normal plant of same age; 2, roots showing maggot injury.

lished the results of an experiment that he had conducted on Long Island. He commended this method of protecting cabbage plants, and his recommendations have been copied or abstracted by a number of entomologists in this country and Europe who have published on this insect. However, this method has not been widely adopted by growers and until recently only a few entomologists have endeavored to demonstrate its practicability. Schöyen [12] of Norway gives an account of an unsuccessful test with tar pads in which checks and treated cauliflowers were equally injured. Blair [13] of Canada reports in detail the results of an experiment in which only 15 per ct. of the protected cabbage resulted in fair or vigorous plants. As the experimental plat was little better than the check, he attributes the failure to the possiblity that the tar pads were applied too late. In his report for 1907 Smith [14] says "tarred-paper disks were distinctly effective. Several hundred were used, all told, and . . . on only two plants were maggots found later." In a summary of the following seasons' work he again remarks [15] "As a protection to the cauliflower and cabbage plants, the tarred-paper disks proved to be both practical and effective." Washburn [16] describes an experiment in his report for 1907–08 that was decidedly unfavorable to tar pads and states that similar results were secured in 1906. This failure is attributed to the use of tar paper instead of tarred felt for the protective disks. He later secured some tarred felt cards from Smith Brothers of Green Bay, Wisconsin, which were placed about cauliflower seedlings on May 23. Of these plants 77 per ct. of the protected and 67 per ct. of the check plants produced heads. Britton and Walden [17] in a summary of tests covering several years state "these disks have given the best results of any form of treatment." Caesar [18] of Ontario, Canada, gives the results of a test in which 648 tarred disks were used and 90.6 per ct. of the protected plants lived as compared with 42.6 per ct. of the checks. He states that the pads were a great success; and that the differences in the treated and untreated lots were greater than the figures would indicate.

[12] Schöyen, W. M. Beretning Skadeinsekter og Plantesygdomme, p. 23. 1896.
[13] Canada Exp. Farms Rept. 1904, p. 362.
[14] N. J. Exp. Sta. Ann. Rept. 1907, p. 439.
[15] N. J. Exp. Sta. Ann. Rept. 1908, p. 357.
[16] Minn. Exp. Sta., Bul. 112, p. 202. 1908.
[17] Eighth Rept. State Ent. of Conn., p. 835. 1908.
[18] Ontario (Canada) Agricultural College. 37th Rept. p. 40. 1911.

Commercial tests with tar pads during 1912: Test No. 1.—This test was located north of Geneva on the truck farm of Mr. Henry Cook. On May 14 tar pads were placed about four hundred and thirty plants on five alternate rows of a small field of cabbage. The intervening rows were left as checks. There was no injury by maggots, and on July 8 there was no difference in size or appearance of the plants in the check and treated rows.

Test No. 2.— This test was located east of Geneva in a cabbage field on the truck farm of Mr. Charles Scofield. Four hundred disks were applied to four alternate rows of plants on May 22. The period of oviposition commenced somewhat before this date, and as the plants had been set two days before treatment it was possible for them to become infested with eggs before the papers were applied. The injury by maggots, as evidenced by the wilting and death of some of the plants, was very noticeable on June 21. At this time 10 per ct. of the checks and 1 per ct. of the treated plants were either killed or badly wilted. In addition to this difference in the percentage of plants seriously injured, there was also another perceptible result, namely, the cabbages in the protected rows averaged slightly larger than those of the check rows. The smaller size of the checks was attributed to the work of maggots, which were generally observed about the roots of the untreated plants. It appeared that while the insects were not sufficiently numerous to kill the cabbages, enough of them were present to retard their growth.

Test No. 3.— This was located near Geneva in one of the plantings of Mr. Geo. Gasper. Four hundred disks were placed on four alternate rows on May 15, the day following the setting of the plants. The soil was a clay loam and was somewhat lumpy because of the unfavorable conditions at the time of cultivation, and in addition the plants were set low in the ground, which made it difficult to attach the tarred disks. The cards were soon covered by a half inch or more of earth, due to the washing of the soil during a heavy shower. By June 20 many of the plants were wilted and some were dead as a result of the injury by the maggots. Careful counts on this date showed that 5½ per ct. of the treated plants and 16 per ct. of the checks were either killed or missing. In addition to this difference the protected plants were slightly larger than the checks.

Test No. 4.— This experiment was located about three miles northeast of Geneva in a cabbage field belonging to Mr. William Baker. The field consisted of twelve rows, having about three hundred plants to the row. On May 11 tar pads were attached to the plants in two rows. On June 21 many of the untreated plants showed the effect of maggot work. Eight per ct. of the checks and two-thirds of one per ct. of the treated plants were badly wilted or killed. Here again the protected plants were larger than those in the adjacent rows.

Commercial tests with tar pads during 1913: Test No. 1.— This experiment was conducted on the farm of Mr. Henry Cook, north of Geneva. Four hundred tar pads were applied to four alternate rows, but maggots were present in such small numbers that there was no difference between the treated and check plants. Attention is called to the fact that for two successive seasons no noticeable injury by maggots occurred on this farm, although on neighboring farms the pest has, during both seasons, done a great amount of damage.

Test No 2.— This planting of cabbage belonged to Mr. William Baker and was located a short distance from the field mentioned in Test No. 4 of the previous season. The soil was a light sand and well tilled. The seedlings were of good size, with long straight stems. The cabbages were planted on April 29 and 30. On May 3 about seven hundred tarred disks were placed on six alternate rows. During the following two weeks adults of the cabbage maggot were numerous in this field and eggs were observed in conspicuous numbers about the stems of the plants. By June 5 there was a very marked difference between the treated and check rows. Many of the cabbages in the untreated rows were wilted or dead and the plants averaged much smaller than those protected by tarred disks. This condition is well shown in Plates XXI, XXII, XXIII. The plants illustrated in Plate XXIV were given the same care in all particulars, and the difference in their comparative size is due to the continued root injury by a few maggots, which was sufficient to check their growth. It was estimated on June 9 that 93 per ct. of the protected plants and 45 per ct. of the checks would make marketable heads. The results in yields and financial returns from the treated and untreated rows in this experiment are shown in detail in Table III.

TABLE III.— YIELDS OF CABBAGE FROM TREATED AND UNTREATED ROWS ON THE BAKER FARM IN 1913.

Plants protected by tarred papers.				Plants not protected.			
Number of row.	Number of seedlings planted.	Number of heads sold.	Computed yield per 1000 plants set.	Number of row.	Number of seedlings planted.	Number of heads sold.	Computed yield per 1000 plants set.
1.......	119	90	....	2	127	24	....
3.......	110	84	....	4	111	26	....
5.......	108	82	....	6	126	28	....
7.......	121	84	....	8	109	25	....
9.......	113	70	....	10	122	14	....
11.......	98	74	....	12	93	18	....
	669	484	723	....	688	135	193

From the above table it will be observed that 72 per ct. of the cabbages protected with tar pads were sold on the early market as compared with about 19 per ct. of the plants not treated. By computing the gain per 1,000 plants, on the basis of the above experiment, we secure the following results:

1,000 protected plants yield 723 marketable heads.
1,000 check plants yield 193 marketable heads.
Gain due to tar pads 530 heads.
The above mentioned cabbage was sold at $8\frac{1}{3}$ cents per head.

Value of 530 heads at $8\frac{1}{3}$ cents..............	\$44.17
Cost of protecting 1,000 plants with tarred papers..................................	1.40
Net profit per 1,000 protected plants........	\$42.77

Conclusions from experiments with tar pads.— The experiments briefly described have shown that the employment of tar pads is an efficient method of reducing losses to early cabbage from maggots. The actual amount of protection secured by this means has varied with different farms according to the severity of the attacks by this pest, but in plantings where the maggots were abundant and very

destructive to untreated cabbages, a large percentage of the plants protected by card disks have produced marketable heads. This method of protecting early cabbage is simple, and when compared with the losses which some truck growers have sustained in certain trucking sections it is, moreover, quite inexpensive. In addition to actually reducing the number of plants killed by the insects another important result of the experiments should be noted, that tar pads have largely prevented root injury, which though not sufficient to kill the plants may be extensive enough to retard growth and the maturing of the cabbages, so that the crop fails to reach the earliest market when usually the highest prices prevail. This is an important consideration, which in the past has not been sufficiently emphasized or really appreciated by most truckers.

Comparative merits of carbolic-acid emulsion and tar pads.— The chief merit of carbolic acid in controlling the cabbage maggot is that it will kill the eggs and young larvæ of the insect. The disadvantages attending the use of the emulsion are that several applications are usually necessary, the liquid must be applied in sufficient quantities to penetrate the soil in order to reach the insects; and, of most importance, that there is danger of injury to the tender roots of the plant. Carbolic acid is a strong poison and our tests as well as those of other workers have shown that even at the dilutions used the roots of cabbages may be injured. A very serious objection to this method of treatments is that in actual practice truckers do not apply the emulsion until the injurious work of the maggots is in an advanced stage and the plants are damaged beyond recovery. The tar pads, on the other hand, can be applied immediately after the plants are set in the field and require no further attention. They are safe, in that there is no possible chance of injury to the plant by their use, and in our tests they have also given efficient protection against the cabbage maggot. It has proven much more easy to apply the tar pads than it is to make a single treatment of the emulsion, for one man can carry to the field enough tar pads to protect one thousand plants, while to treat this number of cabbages with carbolic-acid emulsion would require at least two and one-half barrels of the liquid.

Cost of protecting cabbage with tar paper disks.—As to cost, the single-ply tarred felt disks have in the past been offered for sale at about seventy cents per thousand. In our experiments on sandy

soil with plants of desirable size, one man was able, without any previous experience, to adjust the pads carefully at the rate of three hundred of them per hour. On the basis of these items the cost of protecting cabbage by this method will run approximately from \$1.35 to \$1.50 per thousand plants. In addition to the expense for protectors and labor, the actual cost will also vary according to the character and condition of the soil as well as in the manner in which the plants are set in the ground. Plants that are set low in the ground or are wilted are not adapted to this method of protection.

Considering the safeness to the plant, the ease of application, cost and protection against the maggot, the use of tar pads seems to be the most practical method yet devised for protecting early cabbage from this insect.

DESCRIPTION OF TAR PADS AND THE TOOL FOR MAKING THEM.

The cards are cut in the shape of a hexagon (Fig. 19) from roofing paper known as "single-ply tarred-felt." The tool used in cutting these disks can be made by an expert blacksmith by reference to the accompanying figures. The blade or cutting edge is formed from a band of steel bent in the form of a half hexagon, with an additional strip reaching from one end nearly to the center, as shown in Fig. 20. The part making the star-shaped cut is formed from a separate piece of steel bolted to the handle and so attached as to make a close joint with the blade. The edge of the blade is beveled from the outside all around, so that by removing the part making the star-shaped cut the edge may be sharpened. It is important that the angles of the cutting edge be made perfect and that its outline represent a half hexagon.

In order to cut the disks the tarred paper should be placed on the end of a section of a log or piece of timber (Fig. 21) and the lower edge notched, as indicated in Fig. 22, using only one angle of the tool; then begin at the left side, placing the cutting edge as shown by the dotted line. One man can cut from 300 to 500 disks per hour and about 6 pounds of single-ply tarred-felt is necessary for a thousand pads. Estimating the paper at 2½ cents per pound and the labor at 15 cents per hour, makes the cost of the pads per 1,000 about 15 cents for material and 30 cents to 50 cents for labor.

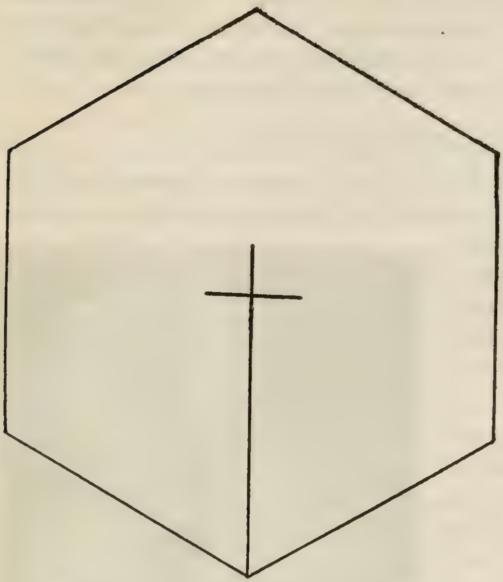

Fig. 19.— Shape and Size of Tar Pad.

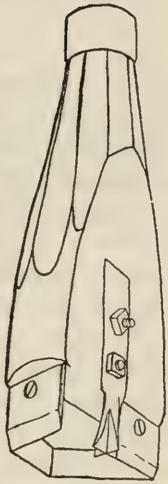

Fig. 20.— Tool for Cutting Tar Pads.

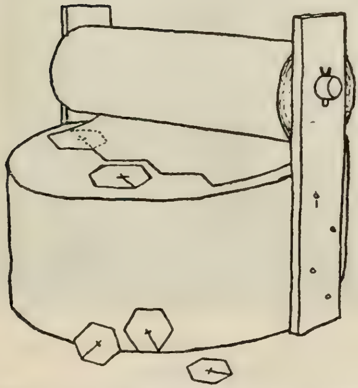

Fig. 21.— Cutting Block and Paper in Position for Making Tar Pads.

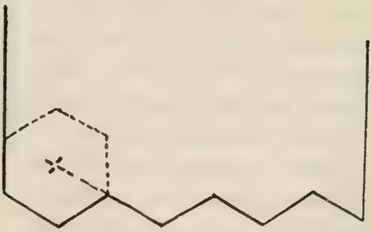

Fig. 22.— First Steps in Cutting Tar Pads.

Truckers who do not care to cut their own disks may purchase them from Hirsch Brothers, Middle Village, L. I., New York, A. B. Cowles, 25 S. Water St., Rochester, N. Y., and Smith Brothers, Green Bay, Wisconsin. In large trucking sections there are doubtless agencies who keep these protectors in stock.

RECOMMENDATIONS.

In the employment of tar pads as a means of protecting early cabbage, truckers should arrange to transplant seedlings of good size with rather long stems. Disks cannot be satisfactorily adjusted about small plants, for in setting such seedlings it is necessary to place them low in the soil so that only the leaves protrude. Moreover, while transplanting it is well to avoid placing the seedling in a depression. This frequently occurs when the work of setting is done by hand, for in making a hole for the roots more earth is removed than is necessary, so that after the operation is completed the plant occupies the center of a shallow basin. Tar pads placed about cabbages that have been set in such situations are liable to become covered with soil during the first shower, which reduces their efficiency.

FIG. 23.— TAR PADS PROPERLY ADJUSTED ABOUT CABBAGES.

Some growers set their cabbage plants on a slight ridge. This practice is an advantage where tar pads are used, as the protectors are not liable to become covered with soil.

To secure the greatest benefit the tar papers should be applied immediately after the plants are set in the field. If this work is delayed for several days it gives the flies an opportunity to deposit numerous eggs about the plants.

The method of applying the card is to separate the two edges of the slit running to the center, slip the card around the plant after it is set, and see that it fits snugly about the stem. The paper pad should then be pressed down firmly so that the under surface will be in contact with the soil, and the radial opening closed. (Fig. 23.)

In the use of tar pads the more important points to keep in mind are to set good-sized plants, place them on a ridge rather than in a trench, and attach the tar papers at the time the seedlings are transplanted.

In experimental efforts by truckers to determine the practicability of protecting early cabbage by the above method, we advise that the tar pads be applied to alternate rows, leaving the intervening plants as checks. Under this system the benefit derived from the protectors is likely to be more clearly shown than when the experiment is conducted with detached plats.

SUSCEPTIBILITY TO SPRAYING MIXTURES OF HIBERNATING PSYLLA ADULTS AND THEIR EGGS.*

H. E. HODGKISS.

SUMMARY.

Investigations of failures to control the psylla in pear orchards led the Station to inquire into the susceptibilities of the hibernating adults and their eggs to spray mixtures.

Studies of the seasonal history and habits of the insect showed that the pear psylla passes the winter as an adult or "fly," and that it deposits its eggs in the spring within a short period after its emergence from hibernating quarters. The psylla was observed to winter over on various fruit trees such as apple, cherry, plum and peach, but the largest number of the "flies" sought hibernation in the rough bark of pear trees.

The behaviour of the hibernating "flies" in the fall was quite different from the movements of the insects in the spring. During a period in late fall or early winter when the weather moderated it was observed that few of the "flies" remained in hiding and that they largely clustered in the center of the trees. At such times the adults walked but were sluggish in their movements and rarely attempted to jump or fly. On the contrary, during the spring, as a result of constantly increasing temperatures and the daily effectiveness of sunlight, a few hours of time proved sufficient to induce great activity among the adults. It was not uncommon for them to jump or fly directly after emergence from their winter retreats.

If moderate temperatures prevailed eggs were largely deposited within a few days after the emergence of the hibernating adults in the spring. Oviposition continued for several weeks, especially if the weather was variable, but usually most of the eggs were deposited before the last of April. Some ova were laid on foliage, but it appeared that these normally are comparatively few in numbers and result in little or no serious infestation of the foliage.

* Reprint of Bulletin No. 387, May; for Popular Edition see p. 938.

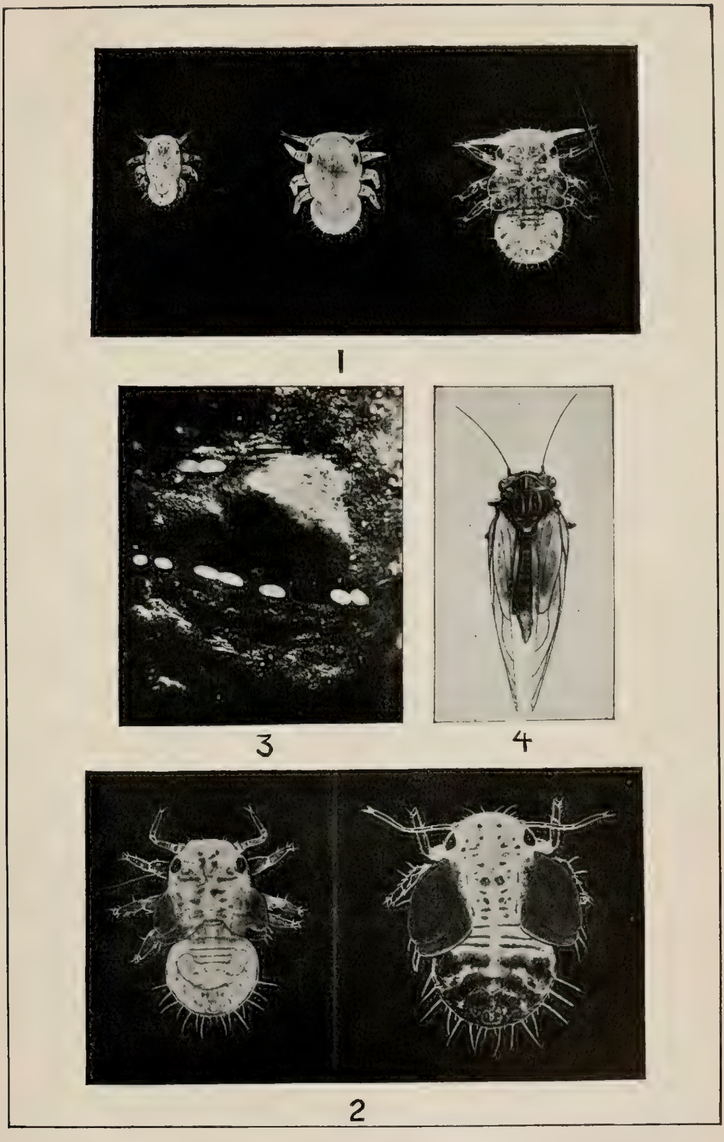

PLATE XXV.—THE PEAR PSYLLA:
1, Nymphs, stages 1-3; 2, nymphs, stages 4-5; 3, eggs; 4, winter adult.
(All figures much enlarged).

The practice of clean culture and the removal and destruction of the rough bark left the "flies" with few opportunities of escape from applications of contact mixtures. Miscible oils, nicotine preparations and soapy solutions were effective sprays against the psylla adults. Homemade oil-emulsions were less satisfactory, which may have been owing to varying percentages of oil in the mixtures, caused by imperfectly prepared emulsions.

The best means of killing the "flies" is spraying during a period of warm weather, preferably in November or December, or during March or early in April. The most satisfactory mixture, from the standpoints of safety to fruit and leaf buds and effectiveness against the insect, is three-fourths of a pint of tobacco extract (40 per ct. nicotine) in 100 gallons of water to which are added from three to five pounds of soap.

Eggs about to hatch and newly emerged nymphs succumb to an application of the lime-sulphur solution. By postponing the dormant treatment for the San Jose scale until the blossom cluster-buds are beginning to separate at the tips, very effective work can be done against the eggs. The lime-sulphur should be used in the proportion of one gallon of the concentrate, 32° B., to eight gallons of water. In some tests of other contact sprays the miscible oils, oil emulsions, weak dilutions of nicotine, and soapy solutions were of small value for the destruction of the eggs. Ova deposited on the twigs after the wood was thoroughly sprayed with the lime-sulphur solution hatched, and the young nymphs were not harmed through contact with the material on the bark of the trees. On the other hand the wash having considerable amounts of sediment (15–20–50 formula) was less destructive to the eggs but the young psyllas which hatched for the most part failed to reach the opening buds and these succumbed to the action of the sediment which became attached to their bodies after leaving the egg shells.

The chief factors which make for efficient work against the hibernating "flies" and their eggs are (1) a knowledge on the part of the grower of the habits of the "flies" and an acquaintance with the eggs; (2) an understanding of the conditions under which these stages are most vulnerable to sprays; (3) thorough work in spraying.

INTRODUCTION.

Failures to control psylla in pear orchards by summer spraying to destroy the nymphs only, have led the Station to inquire into the susceptibility of the insect to spraying mixtures at other stages of its life. Attention has been given especially to the hibernating adults and to the eggs of this brood, for it has seemed on casual observations that these, under certain conditions, might be quite vulnerable to treatment. This conviction was further strengthened by a study of the literature on the species, which has indicated the possibility of protecting orchards by combating the insects in either of these stages, and has emphasized the desirability of experiments along the proposed lines.

HISTORICAL SUMMARY OF SPRAYING FOR ADULTS AND EGGS.

In 1896 Dr. J. B. Smith[1] of the New Jersey Station suggested that " the application of whale-oil soap early in the spring, just as the buds begin to swell, will generally kill the insects (hibernating flies), which are then ready to emerge from winter quarters. Good practice is to scrape all the loose bark from the trees during the winter, and burn it; wash at that time with a potash or strong kerosene mixture, and in the spring use the whale-oil soap at the rate of one pound in one gallon of water, being careful to confine the spraying to the trunk and larger branches. If this is thoroughly done, it forms a film over the trunk which no insect will voluntarily pierce. A liberal application of whitewash is also advantageous * * *."

Prof. M. V. Slingerland[2] in 1899 recommended that " as these hibernating psyllas are the progenitors of all that will appear on the trees during the following season one can readily see how much it means to kill these over-wintering adults before they begin egg laying in the spring. Drenching the bark thoroughly with a strong kerosene emulsion (1 part emulsion to 4 or 5 of water), whale-oil soap (one pound in three to five gallons of water), or kerosene, using about one part of kerosene to nine or ten parts of water, would be a wise investment."

[1]Economic Entomology, p. 138. 1896.
[2]Proc. W. N. Y. Hort. Soc. 44:71. 1899.

In 1911 Dr. J. B. Smith[3] stated " experience has shown that a winter spray of miscible oil, diluted not over ten times, and applied with force enough to penetrate to the bottom of all crevices, produces satisfactory results. I usually recommend that the rough bark be first removed; but if that is done, it is essential that the spraying be done immediately thereafter, and that the scrapings be either burnt at once or thoroughly drenched with the spray. The insects become active enough to crawl at a very moderate temperature, and if scrapings are left lying during an entire sunny day, they may leave them and get among the soil rubbish for a new shelter. On the other hand, the sprayings should not be done at a temperature at or below the freezing point as that impairs the efficiency of the oil."

The eggs of the pear psylla have usually been regarded as quite resistant to sprays which are considered " safe to foliage." Experiments by Slingerland[4] in 1892 with various insecticides such as kerosene emulsion used full strength, or diluted in three parts of water heated to 130° F., pure kerosene, turpentine emulsion at a dilution of one part of the emulsion to three parts of water, pure turpentine, crude carbolic acid emulsion diluted with ten parts of water, resin wash used triple strength, and heated to 130° F., whale-oil soap and sulphide of potash wash used at double strengths, concentrated potash in the proportion of one pound to one gallon of water, or benzine in undiluted sprays, led him to conclude that it is inadvisable to attempt to combat the pest by spraying to kill the eggs. Subsequent experiments by Marlatt[5] in 1894 with various oil-emulsions were more successful, but as a varying percentage of the eggs were unharmed he also laid chief emphasis on the importance of destroying the newly hatched nymphs as the most reliable method of control.

With the general use of the lime-sulphur sprays in the East, commencing about 1902, there have been indications that applications of these mixtures have proven of more or less value in the prevention of injuries by this pest. In 1904[6] some experiments by this Station indicated that these washes had afforded considerable protection

[3] N. J. Agr. Expt. Sta. Rpt. 31:305–6. 1910 (1911).
[4] Cornell Univ. Expt. Sta. Bul. 44:179. 1892.
[5] *Insect Life*. 7:183–4. 1894.
[6] N. Y. State Agr. Expt. Sta. Bul. 262:62–63; 65–6. 1905.

from the first brood of nymphs. In the spring of 1905[7] Mr. Fred Johnson of the U. S. Bureau of Entomology was led to believe that the spring application of the lime-sulphur wash was quite effective in destroying the eggs of this insect in Niagara county. On the basis of his observations of pear orchards in the Hudson River Valley, Dr. E. P. Felt,[8] in 1910, expressed a similar opinion.

In describing conditions in Connecticut during 1904 Dr. W. E. Britton[9] stated "after spraying pear trees with lime and sulphur mixtures to kill the San Jose scale it was noted that the pear psylla was scarce, though the insect was observed in other localities where it caused more or less injury."

In England, Theobald,[10] while working with a closely related species on apple, doubted the value of most washes in killing psylla eggs, and, while apparently he had not tested the lime-sulphur preparations, he recommends the use of a lime-salt mixture for the prevention of the hatching of the eggs. The application is said to act largely as a mechanical barrier to the escape of large numbers of the young, although he suggests that the salt has some osmotic power "as when the quantity of the salt is increased the action becomes greater."

The experiences of some of the leading growers in New York have borne out the promises of the early experiments with the lime-sulphur wash, and the use of this spray in later years seems to have afforded them almost complete protection against the psylla. On the other hand the results in most plantings have been variable and quite contradictory; and in spite of annual sprayings with lime-sulphur wash before the appearance of foliage the pest has, for several seasons, made serious inroads in pear orchards generally. The true explanation for these differences has been wanting, but the discrepancies appear to have been largely due to habits of the hibernating "flies" as affected by seasonal conditions.

Very little was known of the over-wintering adults or the circumstances of oviposition which would appear to be essential for intelligent action. To these points the Station has devoted much attention for the purpose of determining the best conditions for effective spraying against the adults and the eggs deposited by them.

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[7] U. S. Dept. Agr. Yearbook, 1906 (1907). p. 446.
[8] N. Y. State Mus. Bul. 147:45. 1910 (1911).
[9] Conn. State Entomologist. Rpt. 4:213. 1904.
[10] Insect pests of Fruit. pp. 160–162. 1909.

PLATE XXVI.—PEAR TREE BEFORE (1) AND AFTER (2) REMOVAL OF LOOSE BARK.
Removal of bark renders tree less attractive to winter adults of pear psylla.

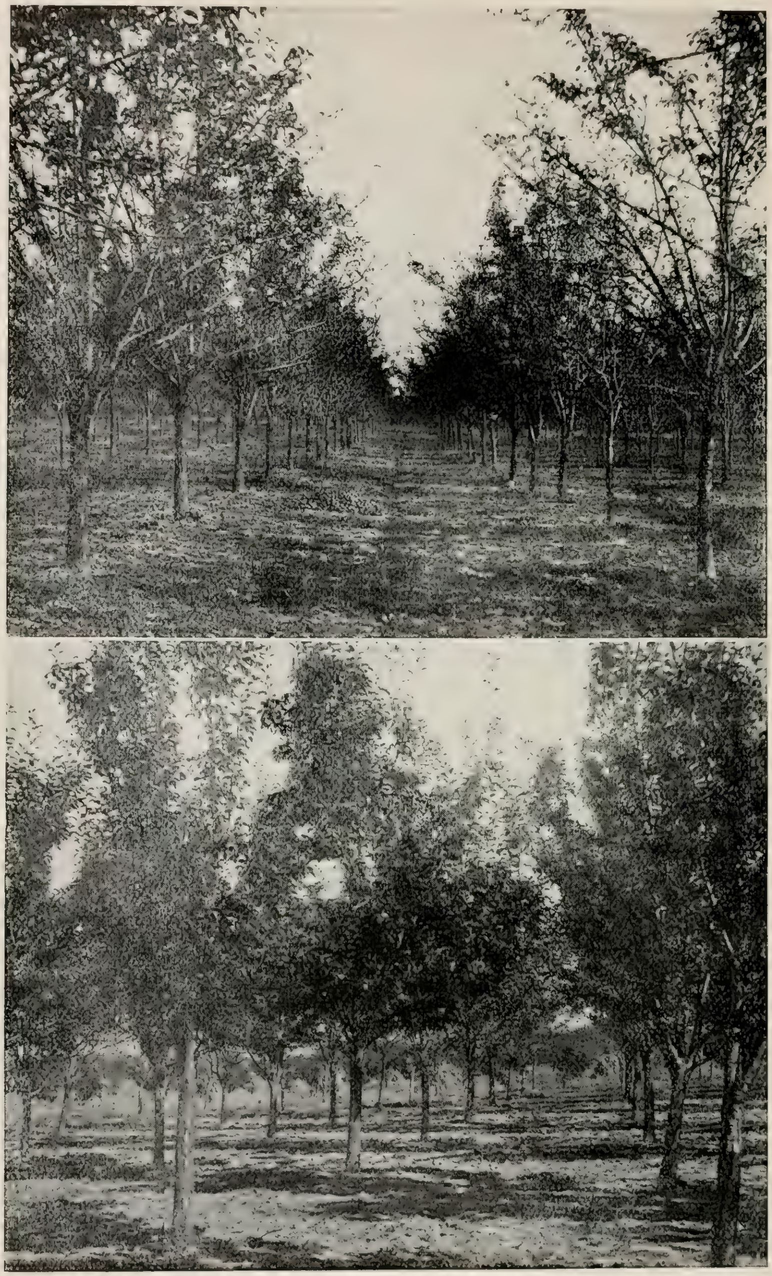

PLATE XXVII.— SPRAYING FOR PSYLLA CONTROL.
Upper.— Unsprayed Kieffer pears defoliated by psylla attacks.
Lower.— Adjoining trees in same orchard sprayed with lime-sulphur solution to destroy psylla eggs.

STUDIES OF THE HABITS AND OVIPOSITION OF HIBERNATING "FLIES."

TIME OF TRANSFORMATION OF HIBERNATING ADULTS.

The abundance of psyllas during the years 1909–1913 afforded ample opportunity to watch the activities of the hibernating brood of this insect. Transformation to winter adults occurred in late September or October of each year as shown in the accompanying table.

Table I.— Time of Transformation of Psylla Adults in the Fall.

	1910.	1911.	1912.	1913.
First appearance of "flies" of winter brood	Sept. 28	Oct. 10	Oct. 10	Sept. 29
Average greatest abundance	Oct. 16	Nov. 3	Oct. 21	Oct. 20
Latest appearance of nymphs of summer brood	Oct. 20	Nov. 12	Nov. 12	Oct. 30

CONDITIONS UNDER WHICH "FLIES" HIBERNATE.

Pear trees of all varieties were equally sought by the adults as food, and sheltered the largest number of these insects. Other kinds of fruits on which hibernating psylla "flies" were often observed were apple, cherry, peach and plum, but the infestation of these fruits was apparently due to their nearness to infested pear plantings. Many adults were also found each year under leaves or other rubbish, and in tufts of grass. In 1912 large numbers of them collected about the "collar" and in some instances in fissures in the soil near the trunks of the trees. Other objects such as fence posts and out-buildings were sometimes found to harbor the "flies" which presumably had crawled to them after having been blown from the trees or having become numbed from the cold and dropped to the ground.

RELATION OF TEMPERATURE TO THE ACTIVITIES OF HIBERNATING "FLIES" IN THE FALL.

The movement of "flies" to winter quarters during the years 1910–1912, of which data are shown in Tables II and III, began with the continued freezing temperatures of October and November. As indicated in Table III this movement was less marked during the

TABLE II.— EFFECTS OF TEMPERATURES ON THE ACTIVITIES OF HIBERNATING PEAR PSYLLA ADULTS IN THE FALL.

(For 1910 and 1911.)

Activities of adults during 1910.	Daily mean temperatures, 1910.	Date.	Daily mean temperatures, 1911.	Activities of adults during 1911.
	° *F*.		° *F*.	
	51	Oct. 25	48	
	43	26	46	
	52	27	41	
	42	28	38	
	36	29	42	" Flies " abundant on trees.
	36	30	46	
" Flies " abundant on trees......	45	31	50	
" Flies " seek lower bud spurs....	42	Nov. 1	41	
	49	2	30	
	39	3	36	Entrance into hibernation.
	35	4	39	
	39	5	41	
	39	6	39	
	35	7	49	
	34	8	48	
	36	9	43	
	47	10	51	
	38	11	55	
	31	12	46	
	32	13	25	
	33	14	27	
Entrance into hibernation....... No " flies " on trees............	34	15	31	Some " flies " on bud spurs during this period, but numbers were small.
	32	16	29	
	34	17	28	
	34	18	36	
	31	19	33	
	31	20	32	
	31	21	31	
	37	22	29	
	32	23	31	
	42	24	38	
	39	25	28	
	35	26	35	
" Flies " emerge from bark......	32	27	42	
	32	28	47	
	35	29	40	
	33	30	30	
	29	Dec. 1	36	
	22	2	34	
	25	3	27	
	27	4	18	
	19	5	32	
	13	6	43	" Flies " emerge in large numbers and remain on bud spurs.
	15	7	44	
	23	8	43	
	17	9	53	
" Flies " re-hibernate and none emerged until spring.	16	10	53	
	16	11	54	
	16	12	50	
	16	13	37	
	26	14	31	
	26	15	38	
	10	16	38	
	15	17	39	
	26	18	31	" Flies " re-hibernate and none emerged until spring.
	33	19	25	

TABLE III.—EFFECTS OF TEMPERATURES ON THE ACTIVITIES OF HIBERNATING PEAR PSYLLA ADULTS IN THE FALL.

(For 1912 and 1913.)

Activities of adults during 1912.	Daily mean temperatures, 1912.	Date.	Daily mean temperatures, 1913.	Activities of adults during 1913.
	°F.		°F.	
	46	Oct. 25	54	
	46	26	46	
	46	27	48	
	46	28	54	
	51	29	49	
	53	30	43	
	46	31	34	
	54	Nov. 1	35	
	38	2	43	" Flies " abundant on trees.
	34	3	46	
" Flies" abundant on trees	41	4	47	
	54	5	47	
	57	6	47	
	58	7	52	
	43	8	52	
	41	9	51	
	43	10	41	
	54	11	33	Entrance into hibernation.
	58	12	38	
	53	13	47	
	53	14	46	
	37	15	37	
Entrance into hibernation.......	35	16	36	
	37	17	41	
	34	18	43	
	46	19	56	
	48	20	60	
" Flies " emerge in large numbers.	52	21	57	
	46	22	65	
	41	23	56	
	39	24	42	
	33	25	38	
	34	26	42	
" Flies " re-hibernate...........	33	27	30	
	27	28	36	" Flies " emerge and remain on lower bud spurs. On coldest days some returned to bark. Final seclusion of adults did not occur until Dec. 29.
	29	29	40	
	38	30	41	
	31	Dec. 1	44	
	43	2	44	
	42	3	44	
	38	4	38	
Some " flies " on bud spurs......	38	5	45	
	53	6	41	
	36	7	45	
	35	8	37	
	20	9	29	
	46	10	31	
	39	11	25	
	23	12	29	
" Flies " re-hibernate and none emerged until spring..........	20	13	43	
	33	14	40	
	42	15	33	
	39	16	37	
	33	17	42	
	41	18	33	
	37	19	26	

autumn of 1913, owing to unusually mild temperatures, and in that year comparatively few " flies " sought protection from the cold before the last days of December.

While the weather was permanently cold during these months the adults remained secluded. In 1910 and 1911 a warm period of several days' duration occurred during the last week of November of each year at which time the unusual warmth during the sunny hours of each day caused myriads of " flies " to leave their hiding places and gather on the bud spurs and tender growth in the center of the trees where they remained although the temperatures at night in the most instances were quite low.

In preparing the tables, the influence of winds, rains and cold storms was not considered, but these factors undoubtedly have obscured the effects of temperature to a considerable extent during some years. It appears from these records that some " flies " after they have once hibernated became active again during the fall or early winter at a mean temperature as low as 32° F., under some conditions, but even at that temperature there was very little activity if colder days had recently occurred. A mean temperature in the fall of about 42° F. usually caused myriads of the "flies" to appear in exposed positions on the trees. Beneath the bark, movement on the part of the insects sometimes was observed at lower temperatures than those indicated in Tables II and III. After the " flies " emerged from shelter they remained semi-dormant on the trees at temperatures less than those at which they emerged from hiding quarters, but it appears from our studies that a mean temperature of at least 40° F., is required to cause the "flies" to leave their shelter during the fall or winter months.

In the spring the susceptibilities of adult psyllas to slight increases in temperature resulted in extensive movements of the insects, very early each season, from their winter quarters to the limbs and smaller branches of the trees. At this period the trees were dormant and the development of the buds had not commenced. Under such conditions the " flies " chose by preference the newer succulent growth within the center of the trees, and the blossom bud spurs about the lower branches. Within a few days, if warmth continued, the " flies " scattered over the trees and disseminated through the orchards. In March, 1910, adults began to jump and fly two days after leaving their hiding places, but during 1911 these activities

TABLE IV.— ACTIVITIES OF HIBERNATING BROOD OF PEAR PSYLLA AND CONDITIONS OF TREES DURING THE SPRING OF 1910.

Date.	Activities of insects.	Condition of trees.	Daily mean temperature.	Weather.	Rain or snow.
			°F.		
March 26	"Flies" appearing		46	Clear, warm	
27			42	Cloudy	
28			59	Clear	
29			62	Clear	
30			69	Cloudy	
31			61	Cloudy	
April 1			42	Clear	
2	Eggs being laid		48	Clear	
3			56	Clear	
4	"Flies" most numerous		52	Cloudy	.08
5		Cluster buds breaking	66	Partly cloudy	
6			59	Cloudy	.02
7	Most eggs; ice storm		33	Cloudy, ice storm	.02 ice
8	drives flies under	Tips of buds separat-	34	Partly cloudy	
9	bark.	ing.	46	Clear	Trace
10			43	Cloudy	.04
11			41	Clear	
12			37	Clear	
13			37	Clear	
14			48	Cloudy	
15			60	Cloudy	.3
16	Many eggs collapsing		58	Cloudy	.09
17			48	Partly cloudy	.5
18		Leaf buds open	51	Cloudy	.06
19	Eggs hatching		43	Cloudy	.74
20	Few nymphs		40	Cloudy	.11
21			48	Cloudy, cool	.07
22		Blossom buds opening	46	Clear	
23			48	Cloudy	.33
24			46	Cloudy	.43
25	Nymphs dying from		47	Cloudy	.55
26	cold and rains.		51	Partly cloudy	.08
27			47	Cloudy	Trace
28			41	Clear	
29			51	Cloudy	.9
30	Nymphs most numer-		54	Cloudy	.02
May 1	ous.		53	Cloudy	.27
2			61	Cloudy	.4
3			45	Cloudy	.52
4	Last flies	Full bloom	45	Clear	
5			46	Clear, warm	
6			48	Clear	
7			57	Clear	
8			51	Clear	Trace
9		Blossoms drop	59	Clear	.07

commenced within twenty-four hours after emergence. It appeared from these observations that the movements of the psyllas depended entirely on heat influences. In 1910 the mean temperature at the time psylla " flies " became active was 46° F. and the insects spread rapidly over the trees. In 1911 the " flies " emerged at a mean temperature of 52° F. During the following week the warmth decreased to 29° F. and most of the " flies " returned to the shelter

TABLE V.— ACTIVITIES OF HIBERNATING BROOD OF PEAR PSYLLA AND CONDITIONS OF TREES DURING THE SPRING OF 1911.

Date.		Activities of insects.	Condition of trees.	Daily mean temperature.	Weather.	Rain or snow.
				°F.		
Mar.	26	" Flies " appearing. .	. . . .	52	Cloudy.	.21
	27	. . . .	. . . .	45	Cloudy.	.34
	28	. . . .	. . . .	28	Cloudy.	.20 snow
	29	" Flies " return to bark.	. . . .	29	Cloudy.	.03 snow
	30	. . . .	. . . .	29	Cloudy.	.29 snow
	31	. . . .	. . . .	27	Partly cloudy. . .	. . . .
April	1	. . . .	. . . .	23	Partly cloudy. . .	.02 snow
	2	. . . .	. . . .	24	Partly cloudy. . .	Trace snow
	3	. . . .	. . . .	28	Clear.	. . . .
	4	. . . .	. . . .	34	Cloudy.	.10
	5	. . . .	. . . .	47	Cloudy.	.06
	6	" Flies " reappear. . .	. . . .	50	Cloudy.	.21
	7	. . . .	. . . .	36	Partly cloudy. . .	Trace
	8	. . . .	. . . .	35	Partly cloudy. . .	.05
	9	. . . .	. . . .	36	Clear.	Trace
	10	. . . .	. . . .	38	Clear.	. . . .
	11	. . . .	. . . .	45	Clear.	. . . .
	12	. . . .	. . . .	47	Cloudy.	.11
	13	. . . .	. . . .	53	Cloudy.	Trace
	14	Eggs being laid.	. . . .	46	Cloudy.	.33
	15	. . . .	Cluster buds breaking.	38	Partly cloudy. . .	Trace
	16	. . . .	. . . .	32	Cloudy.	Trace
	17	. . . .	. . . .	34	Cloudy.	. . . , ...
	18	. . . .	. . . .	43	Partly cloudy. . .	. . . .
	19	. . . .	. . . .	52	Cloudy.	.52
	20	. . . .	. . . .	47	Clear.	.01
	21	. . . .	. . . .	45	Cloudy.	.01
	22	. . . .	. . . .	38	Cloudy.	.03
	23	. . . .	. . . .	42	Partly cloudy. . .	. . . .
	24	. . . .	. . . .	38	Clear.	. . . .
	25	. . . .	. . . .	40	Clear.	. . . .
	26	. . . .	. . . .	56	Clear.	. . . .
	27	. . . .	. . . .	60	Partly cloudy. . .	. . . .
	28	. . . .	. . . .	64	Partly cloudy. . .	. . . .
	29	. . . .	. . . .	63	Cloudy.	.03
	30	Most eggs.	. . . .	61	Cloudy.	.17
May	1	. . . .	Leaf buds open.	54	Cloudy.	.52
	2	Few nymphs.	. . . .	36	Cloudy.	Trace
	3	. . . .	. . . .	35	Cloudy.	Trace
	4	. . . .	. . . .	40	Clear.	. . . .
	5	. . . .	. . . .	44	Clear.	. . . .
	6	. . . .	Blossom buds opening	49	Clear.	. . . .
	7	. . . .	. . . .	55	Clear.	. . . .
	8	Last " flies ".	. . . .	61	Clear.	. . . .
	9	Many nymphs.	. . . .	56	Partly cloudy. . .	.04

of the rough bark. On April 6, 1911, at a mean temperature of 50° F. the " flies " reappeared and did not again seek shelter although on the following day the cold was severe.

A knowledge of the time at which migrations of considerable numbers of the insects may be expected in the spring through a series of years is important since it may serve as a guide to control measures at that period against this stage of the insect. In published accounts of the life history of the pear psylla these activities

TABLE VI.— ACTIVITIES OF HIBERNATING BROOD OF PEAR PSYLLA AND CONDITIONS OF TREES DURING THE SPRING OF 1912.

Date.		Activities of insects.	Conditions of trees.	Daily mean temperature.	Weather.	Rain or snow.
				°F.		
Mar.	26	....	....	23	Cloudy.........	.26
	27	"Flies" on bud spurs	....	38	Clear..........	....
	28	....	....	37	Cloudy.........	.35
	29	....	....	41	Cloudy.........	.34
	30	....	....	33	Clear..........	....
	31	....	....	45	Cloudy.........	.65
April	1	....	....	38	Cloudy.........	.49
	2	"Flies" not active..	....	31	Cloudy.........	2.3 snow
	3	....	....	27	Clear..........	....
	4	....	....	30	Clear..........	....
	5	"Flies" very active.	....	52	Clear..........	....
	6	....	....	63	Clear..........	....
	7	....	....	54	Cloudy.........	.63 snow
	8	....	....	30	Partly cloudy...	.5 snow
	9	....	....	38	Partly cloudy...	2.5 snow
	10	"Flies" under bark.	....	39	Clear..........	.10
	11	"Flies" out, not active............	....	39	Cloudy.........	.14
	12	....	....	36	Clear..........	.05
	13	"Flies" very active.	....	43	Clear..........	....
	14	....	....	50	Cloudy.........	.09
	15	Eggs being laid......	....	63	Clear..........	Trace
	16	....	....	61	Clear..........	....
	17	....	....	45	Partly cloudy...	.07
	18	....	....	53	Clear..........	....
	19	....	Cluster buds breaking.............	43	Clear..........	....
	20	....	....	46	Cloudy.........	....
	21	....	....	48	Clear..........	....
	22	....	Tips of buds separating.............	58	Cloudy.........	....
	23	....	....	48	Partly cloudy...	....
	24	....	....	48	Partly cloudy...	....
	25	....	....	48	Clear..........	....
	26	Most eggs.........	....	51	Clear..........	....
	27	....	....	54	Clear..........	....
	28	....	....	39	Clear..........	....
	29	Many eggs collapsing.	....	40	Cloudy.........	....
	30	....	....	48	Clear..........	....
May	1	....	....	50	Clear..........	....
	2	....	....	50	Clear..........	....
	3	....	....	51	Clear..........	....
	4	Few nymphs........	Leaf buds opening...	52	Clear..........	....
	5	....	....	50	Partly cloudy...	Trace
	6	....	....	62	Clear..........	....
	7	....	....	63	Partly cloudy...	Trace
	8	....	....	65	Clear..........	....
	9	....	....	54	Clear..........	....
	10	Many nymphs......	Blossom buds opening	58	Clear..........	....

have been little discussed and for this reason efforts have been made in our work to secure more abundant data concerning the habits of the winter "flies" during the spring months. In 1910 the great spring movement of the "flies" took place on March 26 in western New York and they remained active until a severe rainstorm accompanied with ice caused them to seek the protection of the bark again. In 1911 the psyllas remained dormant until about April 6,

TABLE VII.— ACTIVITIES OF HIBERNATING BROOD OF PEAR PSYLLA AND CONDITIONS OF TREES DURING THE SPRING OF 1913.

Date.		Activities of insects.	Conditions of trees.	Daily mean temperature.	Weather.	Rain or snow.
				°F.		
Mar.	14	" Flies " appear on buds		57	Clear	
	15	" Flies " very active		53	Partly cloudy	.03
	16			35	Cloudy	Trace snow
	17			23	Cloudy	1.0 snow
	18			37	Partly cloudy	
	19			49	Partly cloudy	Trace
	20			54	Cloudy	Trace
	21	Eggs being laid		51	Cloudy	Trace
	22			45	Clear	
	23			33	Cloudy	.31
	24			40	Cloudy	1.15
	25			49	Cloudy	1.35
	26			44	Cloudy	.99
	27			33	Cloudy	.36
	28			27	Partly cloudy	Snow
	29			38	Clear	
	30			50	Clear	
	31	" Flies " have disappeared		49	Cloudy	.15
April	1	Most eggs		39	Clear	
	2			41	Cloudy	.11
	3			47	Cloudy	.29
	4	Many collapsed eggs.		60	Cloudy	.13
	5			52	Cloudy	.5 snow
	6			34	Partly cloudy	Snow
	7			31	Clear	
	8			36	Clear	
	9			38	Cloudy	
	10	Eggs hatching	Cluster buds breaking	38	Cloudy	.72
	11	Few nymphs		45	Cloudy	.6
	12			49	Partly cloudy	
	13			45	Clear	
	14		Cluster buds separating	46	Clear	
	15			50	Clear	
	16			52	Clear	
	17			46	Cloudy	
	18			55	Cloudy	.27
	19			52	Partly cloudy	
	20	Many nymphs		33	Clear	
	21			43	Cloudy	
	22			52	Cloudy	.3
	23			63	Cloudy	.3
	24		Leaf buds opening	68	Clear	
	25			66	Clear	
	26			69	Clear	
	27			60	Cloudy	.96
	28		Blossom buds opening	51	Cloudy	.83

and in 1912 few adults were seen until April 11. The earliest extensive migration of which record was obtained in any year occurred on March 14, 1913, but many " flies " were destroyed by storms and extreme cold later in the month. The final emergence of the " flies " in the spring from their winter quarters and their subsequent activities for the four-year period are given in Tables IV–VII.

OVIPOSITION OF THE HIBERNATING BROOD OF "FLIES"

The eggs of the pear psylla are of small size and the act of oviposition is seldom observed owing to the smallness of the insects. At the beginning of oviposition the trees were dormant and the eggs were laid on the wood in crevices in the bark around the bases of the blossom buds or on the stems. The habit of the "flies" of collecting in large numbers on water sprouts often resulted in noticeable quantities of eggs being deposited on such growth and in 1910 they were sufficiently numerous in these locations to attract the attention of orchardists to the infestation. Eggs were the most abundant on the under side of twigs and small branches, which appeared to be due to the protection from cold and winds afforded to the "flies" by these situations.

The young foliage was sought by the "flies" as a place of deposition for their eggs as soon as the buds opened, and as the season advanced belated adults deposited eggs only on foliage. The psyllas seemed to choose by preference the midrib of the leaves and blossom stems for that purpose. Young fruit stems also were selected by them for the lodgment of their eggs. These normally were comparatively few in numbers and resulted in little or no serious infestation of the foliage.

Egg-laying usually began within a few days after the spring migration of adults from winter quarters occurred and extended over a period of several weeks. Most of the eggs, however, were usually deposited within two weeks from the time oviposition commenced. In 1910 a large number of the eggs were laid about April 7. The greatest numbers of eggs in 1911 were seen on April 30, while in 1912 most of the eggs were deposited before April 26. In 1913 they were abundant on April 1 with only a slight increase later in the month.

As to the time required for the hatching of these eggs Slingerland[11] states that in 1892 eggs were being deposited on April 7, some of which were taken to his office where they hatched in eleven days. At Geneva some laboratory breedings of psylla eggs were made during 1911, the results of which are presented in the following table.

[11] Cornell Univ. Expt. Sta. Bul. 44:168. 1892.

TABLE VIII.— INCUBATION PERIOD OF FIRST BROOD EGGS OF PEAR PSYLLA UNDER ARTIFICIAL CONDITIONS.

Lot No.	Number of eggs.	Date of deposition.	Date of hatching.	Period of incubation.
I	207	Mar. 30	April 10	12 days
II	44	April 1	April 11	12 days
III	100	April 6	April 18	13 days
IV	100	April 8	April 19	11 days
V	64	April 13	April 23	11 days
VI	45	April 15	April 25	11 days
VII	38	April 12	April 19	8 days

The indoor temperatures in these tests were very favorable for early hatching of the eggs. Out of doors in New York the normal temperatures during April are apt to be low and consequently the incubation period of psylla eggs is usually longer. According to Slingerland's[12] observations eggs, of this species deposited on April 7 hatched on May 10. At Geneva some records were obtained on the duration of the egg stage in 1911 under natural conditions which are given in the accompanying table.

TABLE IX.— HATCHING OF FIRST BROOD PSYLLA EGGS UNDER NATURAL CONDITIONS DURING 1910.

Lot No.	Number of eggs.	Date of deposition.	Date of hatching.	Period of incubation.
I	354	April 3	April 20	18 days
II	238	April 4	April 21	18 days
III	578	April 15	May 2	18 days
IV	209	April 18	May 4	15 days
V	451	April 30	May 11	12 days

From this table it would appear that about eighteen days was the usual incubation period for eggs deposited during the early days of April, 1910, but the time required for the development of the ova became less as the warm days of May approached. In our observations over several years we have noticed that normally psylla eggs hatch in about three weeks but this period is some-

[12]Cornell Univ. Expt. Sta. Bul. 44:168. 1892.

what extended if cold days prevail soon after deposition takes place. On the other hand warm weather seems to hasten the development of the eggs. The retardation and acceleration of the incubation period because of weather conditions perhaps explains the almost simultaneous hatching of psylla eggs which we have observed in orchards in western New York during April or May of the years 1911 to 1913. The records during these years are as follows: 1910, April 19; 1911, May 2; 1912, May 4; 1913, April 10.

INFLUENCES OF NATURAL AGENCIES ON NUMBERS OF HIBERNATING "FLIES" AND THEIR EGGS.

Fungus disease.— During the spring of 1911, small numbers of the hibernating brood of psylla "flies" died soon after emergence. Dead and inactive adults from orchards in Niagara county showed upon examination the presence of a parasitic fungus, *Empusa* sp. Collections of the "flies" taken at random from the trees showed that about 2.5 per ct. of them were affected by the disease. Casual observations have indicated that the fungus normally has but little influence on the numbers of the psylla.

Egg parasites.— A number of breedings have been made to determine if the eggs of this insect are subject to parasitism, but our studies so far have failed to find evidence of an egg parasite. It would appear that parasites of psylla eggs, if they occur, are unimportant and these observations are included chiefly as a matter of record.

Infertility of eggs.— Numerical counts were made to determine the percentage of hatching of psylla eggs. The eggs used for this purpose were those laid on the bud spurs and they were hatched under natural conditions. The following figures show the number of collapsed eggs as compared with fertile ones in these counts:

Table X.— Showing Results of Counts as to Comparative Numbers of Fertile and Infertile Eggs.

Sound eggs.	Collapsed eggs.	Infertile eggs.
No.	*No.*	*Per ct.*
2522	175	6.4
685	65	9.0
1628	123	9.8
1000	80	7.4
2763	225	7.6

Weather influences.— Weather greatly affects the activities and numbers of the insect. The influence of temperature in the movements of adults and egg deposition have previously been shown. The following notes are of interest as showing the effects of storms and other conditions upon other habits as well as the numbers of the insect. On March 26, 1910, adults emerged from winter quarters and appeared on pear trees and during the first week of April deposited thousands of eggs. On April 7, 1910, a cold rain occurred at Lockport which coated the trees with ice and on the following day few " flies " were observed upon the trees. A small number of these adults were caught in the ice or dropped to the ground where they perished in the soft earth beneath the trees. Many of them, however, were apparently able to find some protection and on April 20 the trees were reinfested. In 1911 a warm period occurred during the week ending March 9, and " flies " appeared in considerable numbers. During the following night a drenching rain washed thousands of the " flies " to the soft ground where they died. On April 8, 1912, the adult psyllas which were out in full numbers in the tops of the trees were caught by a sudden change of weather and many, numbed by the cold, dropped to the muddy ground beneath from which they were unable to extricate themselves.

In a letter dated March 31, 1913, Mr. F. S. Hayden of Wyoming, N. Y., stated that a cold, freezing rain on March 26 had coated the pear trees in his orchard with ice, and during the warmer days which followed only from one-third to one-fifth of the original infestation of adult psyllas appeared on the trees after the storm. On March 22, 1913, according to Mr. A. B. Buchholz of the State Bureau of Horticulture, a sudden drop in the temperature so numbed the " flies " that they dropped to the ground and later collected in swarms about the " collar " of the trees. In the Collamer orchard at Hilton we have frequently observed in early spring large numbers of the adults under weeds and rubbish beneath the trees or at the " collars " of trees near the surface of the ground. Their presence in these situations we have attributed to the same cause. Mr. L. F. Strickland, also of the State Bureau of Horticulture, reported that in Niagara county a heavy driving rain on March 24, 1913, washed thousands of " flies " from pear trees and in some instances the insects appear to have almost entirely disappeared. The actual

influence of the weather conditions as described must obviously vary greatly according to seasonal conditions, but there is little doubt that ice storms, cold, driving rains, and strong winds do, under certain circumstances, greatly reduce the number of " flies " and thereby lessen the extent of egg deposition.

STATION EXPERIMENTS TO DETERMINE THE SUSCEPTIBILITIES OF HIBERNATING "FLIES" AND THEIR EGGS TO SPRAYING MIXTURES.

FALL AND EARLY WINTER SPRAYING AGAINST HIBERNATING ADULTS.

During 1911, experiments were conducted in the pear orchards of the Middlewood Farms at Varick, Seneca county, to determine the value of the fall spraying as a means of reducing the numbers of " flies " going into hibernation. The plantings comprised about 800 twenty-year-old Bartlett pear trees which had been severely injured by psyllas during the summer. Spraying commenced on December 6, and was continued at intervals, as weather permitted, until December 18, during which period thousands of the insects were clustered on the untreated trees. The spraying mixtures used in these tests were tobacco extract (40 per ct. nicotine), fish-oil soap and lime-sulphur solution, used separately, and each of the latter two in combination with the tobacco extract. The nicotine preparations were diluted at the rate of three-fourths of a pint of tobacco extract (40 per ct. nicotine) to one hundred gallons of water, or lime-sulphur, 32° B., in the proportion of one gallon to eight gallons of water. When the tobacco extract was used alone three pounds of fish-oil soap was added to give spreading and adhering properties. Fish-oil soap was applied in the proportion of one pound to five gallons of water. The concentrated lime-sulphur wash was used at strength for dormant spraying, one gallon of the concentrate to eight gallons of water.

The tobacco preparations and the soap solutions proved very effective. Lime-sulphur wash at dormant strength did not cause marked reductions in the numbers of psyllas, but with the addition of nicotine very effective results were obtained. On warm days which followed the sprayings few "flies" were detected and it was estimated that less than five per ct. of the original infestation of the psylla existed on the trees. During the following spring but

few " flies " emerged and no further applications of sprays were needed to check the operations of the psylla that season. Fall spraying for psylla adults has been repeated in this planting each year since 1911 and is relied on entirely by the owner for the protection of the pear orchard from the pests.

On the basis of the above results a number of experiments along the same lines have been conducted in succeeding years in cooperation with fruit growers. In the main, these later efforts have corroborated the results of the initial tests. Large percentages of the " flies " were invariably destroyed by careful spraying and in isolated orchards, particularly, the work of combating the insect by spring and summer spraying was very much simplified and in some instances was rendered entirely unnecessary. In occasional plantings, because of difficulties due to inclement weather or because of adjoining orchards, these treatments afforded only partial relief and in such cases it was necessary to resort to the usual sprayings the following spring. In none of these tests were miscible or homemade oils applied for fear of damage to the trees. Of the mixtures employed, tobacco extract, soap, and lime-sulphur with tobacco, the tobacco extract (40 per ct. nicotine) has given the most satisfactory results from the standpoints of safeness to the trees and effectiveness against the insects. Applications of soap by a number of growers have given very satisfactory results and have proven somewhat less expensive than the tobacco preparations.

SPRING SPRAYING AGAINST HIBERNATING ADULTS.

During the later days of March, 1910, psylla " flies " appeared in unusual numbers on trees in the orchard of the Collamer Bros. at Hilton. At our suggestion a portion of this planting, comprising about 1530 Bartlett, Kieffer, and Seckel pears of twenty years of age, was sprayed with either kerosene emulsion at the rate of one part of the emulsion to twelve parts of water, or with fish-oil soap in the proportion of one pound of the soap to eight gallons of the water. Applications of these sprays were made during the period of March 21–26 at which time the psylla adults were quite active and had spread over the trees.

The application of the kerosene emulsion did not appreciably lessen the numbers of adults as compared with those on adjoining unsprayed blocks of pears, where there were myriads of the " flies "

clustered on the branches in the lower parts of the trees, which may have been due to varying percentages of oil in the mixtures caused by imperfectly prepared emulsions. The trees subsequently received an application of fish-oil soap which treatment greatly reduced the severity of the infestation, and fewer eggs were deposited in this section than in unsprayed portions of the orchard.

In the spring of 1911 spraying experiments against the " flies " were conducted in the Kieffer pear orchard of Mr. L. B. Wright at Hilton. The rough bark had been removed from the trees during the previous year, which left small opportunity for the protection of the insects from the sprays. As soon as the adult psyllas appeared the trees were sprayed with either miscible oil at dilutions of 1–10 or 1–15, or fish-oil soap in the proportion of one pound of the soap to four or five gallons of water. About 800 trees were used in these experiments and the treatments resulted in large reductions of the numbers of the "flies" in the orchard. Very little difference in the effectiveness of the various dilutions of miscible oil were observed. A slightly greater benefit resulted from the application of the 1–10 dilution, which seemed hardly sufficient to compensate for the added expense of the treatment. Fish-oil soap in the proportions used gave very satisfactory results. A few " flies " escaped from the treatments but no apparent harm was caused to the planting through the natural increase of the insects as the season advanced.

In the spring of 1911 experiments along these general lines were conducted in about twenty-five orchards in cooperation with pear-growers. In these tests miscible oils, homemade oil emulsions, and soapy sprays were used either alone or in combination with tobacco solutions, or these latter solutions were used alone. These later experiments have reaffirmed the results of the initial endeavors. Careful application of the sprays in nearly every instance resulted in freeing the trees almost completely from the insects. In occasional plantings, because of adjoining infested orchards, the treatment afforded only partial relief and in such instances it was necessary to resort to a later treatment. Of the mixtures employed, the soap solutions and the tobacco extract (40 per ct. nicotine) with soap have given the most satisfactory results from the standpoints of safeness to the trees and effectiveness against the psyllas. The homemade oil-emulsion proved to be much less satisfactory as

a spray for the "flies" and orchardists using this spray invariably had to resort to later sprayings in order to control the insects.

BANDING TREES TO TRAP PSYLLA "FLIES."

During the fall of 1910 some experiments were conducted in the orchard of Mr. L. B. Wright of Hilton to determine the practicability of using bands on trees as traps for psylla adults. Forty trees were used in the experiments. Strips of building paper about eight inches in width were fastened around the trees in various positions and some were smeared with either tree-tanglefoot or fish glue. Other bands were not coated with adhesives. The glue dried within a few days and later washed from the paper. A few insects were caught on the bands covered with tree-tanglefoot but this material hardened as the cold increased and proved of little value during the fall. In the spring, as the weather became mild, the gummy material softened and on March 21, 1910, some days after the winter adults had emerged, the sticky bands for about two inches from the upper margin were thickly covered with the "flies." Beneath all the papers there were in March thousands of the dead insects.

The banding of the trees as an adjunct to spraying operations was practised against the psylla "flies" during the fall of 1912 by the Collamer Bros. at Hilton. In this work about 2600 trees were banded with tanglefoot fly-paper, placing the gummy surfaces against the bark. The papers were left on the trees for about three weeks and in November the strips were removed to allow thorough applications of contact sprays to the trees. Many "flies" adhered to the bands but the chief advantage of their use in these orchards seemed to be gained through the providing of a convenient hiding place for the psyllas. Myriads of the insects collected beneath the papers and when the bands were removed the psyllas were easily wetted by an application of a soapy spray.

From these tests it appeared that the employment of adhesives was not essential to the success of the traps, although some "flies" were caught on the sticky surfaces. The paper strips to which no gummy material was applied provided an attractive shelter for thousands of "flies" and it has seemed that bands of that description would lessen the difficulties attending the combating of the "flies" in the fall.

EXPERIMENTS TO DETERMINE THE SUSCEPTIBILITY OF PSYLLA EGGS TO SPRAYING MIXTURES.

In a number of orchards sprayed with lime-sulphur during April, 1910, eggs were observed in considerable numbers on the trees and many of them were discolored and in a collapsed condition. A comparison of sprayed and unsprayed trees led to the conclusion that the unusual appearance of the eggs on the treated trees was due chiefly to the spraying they had received. As it was desirable to have data to corroborate these observations a number of experiments were at once undertaken in pear orchards in the vicinity of Lockport and Medina to test the effects of various contact sprays on psylla eggs which are briefly discussed as follows:

Lime-sulphur sprays: Experiment No. 1.— On April 8, 1910, the homemade wash (15–20–50 formula) was applied to a number of pear trees on which psylla eggs had been laid in abundance. On account of the thickened condition of the spray, the trees and eggs were heavily coated by the application. Daily observations were made in the orchard but no change in condition of the eggs was detected until April 15, or about one week after the trees were sprayed. At this time occasional collapsed eggs were observed on check and treated trees and these increased in numbers until April 20 when nymphs began to make their appearance. The eggs on sprayed and unsprayed trees in the same orchard hatched in considerable numbers, as shown in Table XI, but the nymphs on the trees receiving the lime-sulphur treatment for the most part failed to reach the young leaves, and apparently succumbed to the action of the spray after escaping from the egg-shells. The destruction of the young psyllas was so great that the sprayed trees were comparatively free from psyllas during the remainder of the season while the check trees were badly infested and lost their foliage in midsummer.

Experiment No. 2.— Commercial concentrated lime-sulphur solution, 32° B., diluted with nine gallons of water was sprayed on 21 Bartlett pear trees which were rather thickly covered with psylla eggs. Some adjoining unsprayed pear trees served as checks on the experiment. Applications of the spray were made on April 9, 1910, and on April 16 scattering collapsed eggs were observed on treated and untreated trees. On April 20 a few nymphs appeared on the check trees and their number increased rapidly until all

the eggs had hatched. A few nymphs hatched on sprayed trees but the infestation was slight, and was not sufficient to affect appreciably foliage, yield of pears, or development of the buds for the next year's crop of fruit. The percentage of eggs destroyed by the treatment is given in Table XI.

Experiment No. 3.— During the week of May 2, 1911, 400 Kieffer pear trees were sprayed with the homemade concentrated lime-sulphur solution, 26° B., at a dilution of one gallon of the concentrate to six gallons of water. At this time the cluster buds were separating at the tips and the young leaves were unrolling. In making the application care was used to coat thoroughly, with the spray, the bud spurs and smaller limbs and especially the under sides of the branches, for in these situations the eggs were largely deposited. Some eggs were laid on the trees after the spraying was accomplished and late appearing " flies " continued to oviposit on the trees despite the application of the lime-sulphur wash.

Results on eggs.— The destructive effects of the concentrated lime-sulphur solution on psylla eggs was most strikingly demonstrated in this orchard. Collapsed and discolored eggs were abundant on all the trees within a short time after the spraying operations were completed. Eggs deposited on bud spurs after the trees were sprayed hatched and were apparently not affected by the wash which was upon the trees. The percentage of the eggs destroyed by the treatment in this orchard is given in Table XI.

Effects on cluster buds and foliage.— There was a slight amount of burning on young leaves and fruit stems wherever sediment was used in the lime-sulphur, which resulted in the dropping of occasional young blossom stems. The fruit clusters set full and in June there was no noticeable reduction in the numbers of the maturing pears on the sprayed trees. Applications of the clear solution did not harm the fruit clusters and caused only a slight discoloration of the tips of the leaves. No harmful effects to the trees resulted from these injuries to the young foliage, which made a luxuriant growth, and the trees developed plenty of blossom buds for the following year's crop of fruit.

Experiment No. 4.— A block of about 300 Kieffer pear trees received an application of commercial concentrated lime-sulphur solution, 32° B., in the proportion of one gallon of the concentrate to eight gallons of water. The trees were plentifully stocked with

eggs which had been deposited, for the most part, on the under side of the twigs and smaller branches. The spray was applied during the week of May 2, 1911, at the time when the cluster buds were just beginning to break apart at the tips. The trees were thoroughly drenched with the spray and care was exercised to cover the under sides of the limbs.

Results on eggs.— Few eggs survived the action of the spray. Some nymphs were found on the opening buds but the trees, for the most part, were free from the young insects. The natural increase of psyllas which hatched from eggs not destroyed by the spray was slow and the resulting infestation was inconsiderable. On unsprayed pears an abundance of nymphs hatched from the eggs and the trees were wet with honey dew during the remainder of the growing season.

Effects on cluster buds and foliage.— A slight blackening of the tips of the young leaves occurred which was of small importance. No noticeable injuries resulted to the blossom petioles, and young fruits were numerous. The foliage was healthy during the summer and fruit buds developed in goodly numbers. The crop of pears was not large on treated or untreated plats, which was due primarily to the failure of the trees to form fruit buds during the previous year owning to their weakened conditions from earlier psylla attacks.

Experiment No. 5.— In this experiment 2400 Angouleme pears were sprayed with lime-sulphur solution, 32° B., at a dilution of 1–8. Eggs were very abundant on the trees and the deposition had practically ceased when the spraying operations commenced. The applications were made during the period of April 25–28 at which time the blossom clusters were beginning to separate. The small size of the trees permitted a most thorough coating of the limbs and smaller branches with the spray.

Results on eggs.— The treatment resulted in an almost total destruction of the eggs. Owing to their protected situations a small percentage of the eggs which were not hit by the spray hatched and occasional nymphs appeared on the blossom clusters. These larvæ did not increase in numbers and the few infested fruit spurs were subsequently removed before the nymphal instars were completed and the summer brood of "flies" emerged. In August this planting was quite free from psyllas.

Effects on cluster buds and foliage.— A slight browning of the tips of unopened leaves occurred which caused no noticeable ill effects to the trees or fruit. The trees blossomed full and developed a luxuriant growth of foliage. In midsummer the leaves were green and the fruit buds were strong and gave promise of an excellent crop during the following season. The crop of fruit which set was large and the pears were clean, of excellent size and free from the gummy, blackened appearance which ordinarily accompanies the work of the psylla on pear trees.

During the spring of 1911 cooperative spraying experiments for the control of the psylla in the egg stage were conducted in twenty-five pear orchards. In these experiments lime-sulphur solution was the only spray applied since this had proven the most efficient of all the materials used in the previous tests on psylla eggs. Applications of the mixture in the different orchards were made during the last week in April or the first week in May, as the cluster buds were separating at the tips. The results bore out the promises of the earlier tests and in the majority of the orchards all of the eggs, so far as could be determined, were destroyed. In occasional plantings where lack of care was exercised in making the applications of the lime-sulphur a small percentage of the eggs hatched and summer treatments were made to protect the pear trees from injuries by the summer broods. Pear-growers who sprayed carefully were highly pleased with the results obtained from the work and these orchardists have come to depend on the lime-sulphur solution for psylla control in their pear plantings. Other fruit-growers who are each year required to spray for the psylla have adopted this means of control for the insects; and these men, through careful spraying and attention to the egg-laying habits, and to the development of the buds, have secured results which have given them much satisfaction. Pear-growers generally are able through this single spraying for the eggs to protect their crops of pears from the work of the insect during the growing season and insure a good development of the succeeding year's fruit buds.

Tests with other spraying mixtures.— A number of experiments to test the effects of other insecticides in comparison with lime-sulphur were made during the spring of 1910. The additional materials were kerosene emulsion, fish-oil soap, and nicotine prepara-

tions, which were applied in varying dilutions. The effects of the sprays on psylla eggs are given in the accompanying table.

TABLE XI.— EFFECT OF VARIOUS INSECTICIDES ON PSYLLA EGGS.

TREATMENT.	Dilution of spray.	Bud spurs counted.	EGGS COUNTED.		Eggs killed.
			Sound.	Col-lapsed.	
					Per ct.
Lime-sulphur	(Concentrate 1–8)	90	39	2,082	98
Lime-sulphur	(Concentrate 1–6)	75	18	339	94
Lime-sulphur	(Formula 15–20–50)	102	1,806	564	*24
Fish-oil soap	(1–5)	100	232	20	8
Kerosene emulsion	(1–8)	100	900	52	5.6
Miscible oil	(1–15)	100	800	45	5.9
Black leaf extract	(1–30)	100	824	64	7.2
	(1–40)	100	920	48	5
Black leaf 40	(1–1000)	100	810	61	7
Checks	Unsprayed	100	2,522	175	7

* The small percentage of eggs destroyed in this test was presumably due to the lower amount of sulphur in solution in the wash.

In these tests the lime-sulphur solution was the only spray that functioned in any marked degree as an ovicide. Oils and soapy solutions appear not to have caused a decrease in the development of the eggs. The percentage which did not hatch in these instances apparently represented about the normal decrease for that season due to infertility, as shown by the checks.

DISCUSSION OF RESULTS.

Efforts to control the psylla in pear orchards through applications of contact sprays during the summer months have, on the whole, proven unsatisfactory in most plantings. These failures have been due chiefly to the great activity of the adults, the resistance of the old nymphs, and the protection afforded to the nymphs in the more advanced stages by secretions of honey-dew with which they are usually surrounded. There is, moreover, an intermingling of the "flies," eggs and nymphs of the summer brood which render it exceedingly difficult to make much headway against the insects with control measures during those months, since all of these stages of this pest are not susceptible to a single spray mixture which can safely be employed on foliage.

The experiments which the Station has conducted have conclusively shown that the numbers of the psylla can be reduced to insignificant proportions through the adoption of spraying practices against the " flies " or the eggs. In most cooperative efforts orchardists have been able by one thorough application of a spray made against either of these stages to destroy a large part of the infestation, which has resulted in comparative freedom of the trees from the insects during the remainder of the season. In cases of severe infestations other pear-growers have found it advisable to make sprayings for both the " flies " and the eggs. But through attention to the habits of the psyllas and care on the part of the orchardists in making the applications a single treatment has usually proven sufficient for the control of the insect in either of these stages.

The control of the pear psylla through spraying for the hibernating adults and their eggs is accomplished with comparative ease in isolated orchards or small plantings. In localities where orchards adjoin or are somewhat closely situated the control of this pest is usually attended with greater difficulties. Very often a neglected plantation in the neighborhood of well-sprayed orchards serves as a source of infestation. Such a situation provides conditions under which individual orchardists may fail to secure good results from spraying. This difficulty can best be overcome by cooperation among the growers affected, who should act as a unit in carrying out repressive and remedial measures. The chief factors which make for efficient work against hibernating " flies " and their eggs are (1) a knowledge on the part of the grower of the habits of the " flies " and an acquaintance with the eggs; (2) an understanding of the conditions under which these stages are most vulnerable to sprays; (3) thorough work in spraying.

METHODS OF TREATMENT.

SPRAYING MIXTURES AND FORMULAS.

FORMULA 1. TOBACCO EXTRACT.

Tobacco extract (40 per ct. nicotine)	$\frac{3}{4}$ pt.
Water	100 gals.
Soap	3 to 5 lbs.

FORMULA 2. FISH-OIL SOAP.

Fish-oil soap	20 lbs.
Water	100 gals.

These are recommended for fall or spring spraying to destroy the " flies."

FORMULA 3. MISCIBLE OIL.

Miscible oil	7–8 gals.
Water	100 gals.

This is a rather dangerous spray and should be used only in the spring as buds are swelling and never after buds begin to show green at the tips.

FORMULA 4. LIME-SULPHUR MIXTURE.

Lime-sulphur solution (32°–34° B.)	1 gal.
Water	8 to 9 gals.

To be applied just as the blossom cluster-buds separate at the tips to destroy psylla eggs about to hatch and newly-emerged nymphs.

DIRECTIONS FOR SPRAYING FOR THE WINTER "FLIES" AND EGGS OF THE PEAR PSYLLA.

1. *Spraying for hibernating or winter "flies."*— Especial pains should be taken to destroy the pest in this stage, as effective work greatly reduces the number of eggs deposited on the trees and simplifies subsequent spraying operations. The best means of killing the "flies" is spraying during a period of warm weather, *preferably* in November or December, or during March or early in April. A rise in temperature induces the insects to emerge from their hiding quarters and creep to the portions of the trees exposed to the warm rays of the sun and protected from a cold wind. While the insects are able to crawl they are very sluggish in their movements and do not fly. This habit makes them very vulnerable to treatment and the grower should take full advantage of it by so spraying that none of the insects be allowed to escape. To kill the "flies" it is essential to wet thoroughly all portions of the trees, and especial pains should be taken to force the liquid under the loose bark and into all the cracks and crevices in the bark. The experiments have shown the wisdom of spraying one tree thoroughly before proceeding to another. In balmy weather the "flies" may dodge quickly to the opposite side of the tree. By spraying the entire tree they are unable to avoid wetting by the spraying mixture. Treatment late in the fall or winter is especially recommended, as the influence of steadily

FIG. 24.— TOO EARLY FOR MOST EFFECTIVE PSYLLA CONTROL.

decreasing temperatures at this season on the movements of the "flies" makes them especially vulnerable to spraying. In planning for this work select days when there is no danger of the spraying mixture freezing on the trees. The most satisfactory spray from the standpoints of safety to fruit and leaf buds and effectiveness against the insects is three-fourths of a pint of tobacco extract (40 per ct. nicotine) to one hundred gallons of water to which are added from three to five pounds of dissolved soap. (Formula 1).

2. Spraying for eggs of winter "flies."— The eggs about to hatch and the newly-emerged nymphs succumb to an application of the lime-sulphur mixture. In this lies a hint to the fruit-grower for an effective use of this spray against the psylla as well as the scale. The eggs of the psylla are laid principally during April and commence to hatch early in May or when the blossom cluster-buds are beginning to separate at the tips. (Fig. 24.) Most growers spray much earlier than this for the San Jose scale, but by postponing the treatment of pear orchards until the blossom clusters are well advanced (Fig. 25) one may deal an effective blow against the psylla and with the same treatment successfully combat the scale. The lime-sulphur solution, testing 32° to 34° B., should be diluted in the proportion of one gallon to eight or nine gallons of water. (Formula 4.) The spray should be used in liberal quantities and pains should be exercised to wet all portions of the tree, especially the fruit spurs and the under sides of the young wood, where most of the eggs are laid.

FIG. 25.— BEST STAGE FOR SPRAYING TO DESTROY PSYLLA EGGS.

CLEAN CULTURE AND THE REMOVAL AND DESTRUCTION OF ROUGH BARK.

While the adult psyllas seem to prefer to spend the winter under the loose bark of the trees, they may, nevertheless, seek shelter under any waste which affords chances to hide. Matted weeds, tufts of grass leaves, or rubbish on or about the trees present ideal

conditions for hiding places for the insects. Attention to the disposal of such accumulations will greatly aid pear-growers in the spraying for the " flies " especially, through the fewer opportunities offered for the adults to secrete themselves from the sprays.

The rough bark not only provides a shelter for the psyllas during the winter but it also constitutes the chief obstacle to thorough spraying during the dormant season to kill the hibernating " flies." Its removal is desirable for two reasons: first, to render the trees less attractive to the adults for the purposes of hibernation during late fall, winter and early spring; and, second, to facilitate a more thorough spraying of the trunks and lower portions of the larger limbs. The loose bark should be removed by a dull hoe or floor scraper, preferably during a wet period, as the bark is then more easily detached. Care should be taken not to cut into the live tissues as the wounds may become infected with disease. If many psyllas are hiding on the trees the bark should be collected and burned to kill the insects which are attached to the scrapings.

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TREE CRICKETS INJURIOUS TO ORCHARD AND GARDEN FRUITS.*

P. J. PARROTT AND B. B. FULTON.

SUMMARY.

The more common and injurious species of tree crickets in plantings of garden and tree fruits in the State of New York are the snowy tree cricket (***Œcanthus niveus*** De Geer), the narrow-winged tree cricket (***Œ. angustipennis*** Fitch) and the striped tree cricket (***Œ. nigricornis*** Walker). These display great similarity in external appearance but show marked differences in habits and economic status. In common with insects of their kind, during their early nymphal existence they possess pronounced predaceous habits. As they approach maturity they exhibit phytophagous and mycophagous tendencies, subsisting on floral organs, foliage, fruit and minute fungi. The crickets have five nymphal instars. Eggs are deposited during the latter part of August and throughout September. Hatching occurs during early June and the adults make their appearance in August.

The snowy tree cricket oviposits in a great variety of plants. In the region about Geneva eggs are most abundant in apple, plum and cherry, and they are somewhat common in raspberry and walnut. The eggs occur singly in soft, fleshy bark. They are distributed promiscuously and are not arranged in a series in a row. On raspberry, oviposition takes place in the fleshy area at the side of the bud in the axils of the leaves, and usually there is not more than one egg on each side of a bud. This species subsists on a rather wide assortment of foods of animal and vegetable origin. In addition to other species of insects, microscopical examinations of crop contents have shown that the San Jose scale may, under certain conditions, form a large part of the diet of this cricket. It has also been observed to eat holes in raspberry and apple leaves, and is reputed to attack ripening fruits. This species derives its reputation as an orchard pest chiefly from the occurrence of diseased

* Reprint of Bulletin No. 388, May; for Popular Edition see p. 946.

areas about oviposition wounds in the bark of apple trees. The areas of infection in their external appearances and effects resemble superficially certain stages of the common apple cankers. Cultural and microscopical studies indicate that during 1913 a fungus, ***Leptosphœria coniothyrium*** (Fckl.) Sacc., was, in the majority of cases, the infecting organism.

The narrow-winged tree cricket has feeding habits similar to the foregoing species. It is common in apple orchards, and has been observed in considerable numbers on alders and scrub and burr oaks. As with ***niveus,*** various disorders of bark may attend oviposition in apple trees.

The striped tree cricket, unlike the preceding species, prefers, for the reception of its eggs, plants which have a central pith surrounded by a woody outer layer. Oviposition occurs in many plants, but the eggs are deposited most abundantly in raspberry, blackberry, ***Erigeron canadensis,*** and the larger species of ***Solidago.*** The eggs are placed in a series, forming a single row in the current year's growth, and with raspberries have ranged in number from two to eighty or more eggs in a row. This species feeds on anthers and petals of flowers, raspberry leaves and fruit. Leaf tissues, fungus mycelium and spores constituted a large part of the crop contents of a number of specimens that were examined. This species has attained its standing as a destructive pest because of its injurious work on raspberry and blackberry. The injuries it causes arise from the long series of punctures which it produces in canes during the process of egg laying. As a result of the rupturing of woody tissues the cane splits at the point of injury and becomes so weakened that it eventually breaks down from the weight of the upper growth or from twisting by the wind.

These insects have, throughout their normal range of distribution, a number of natural enemies. The most common and efficient of these are egg parasites, of which there are eight species. These are hymenopterons, three species belonging to the Chalcidoidea and five species to the Proctotrypoidea. Of the species of tree crickets discussed, ***nigricornis*** appears to be most subject to parasitism.

Tree crickets are amenable to standard orchard operations. Cultivation to destroy foreign vegetation, as weeds and brush, about and in plantings of fruit, and to keep the ground about trees

and vines clean is an efficient measure for the prevention of damages. While the susceptibility of these insects to arsenicals has not been conclusively demonstrated it is believed that the numbers of the tree crickets are reduced by summer applications of these poisons. Raspberry canes showing extensive oviposition should be removed in the course of winter or spring pruning and burned to destroy eggs contained in them.

INTRODUCTION.

Certain species of tree crickets have long been included in the category of injurious insects, and economic treatises seldom fail to contain an account of them. But as common and widely distributed as are these creatures, no little confusion has existed as to their identities, and moreover there has been very little detailed knowledge of their various activities as fruit pests. The studies herein described were undertaken for the purpose of ascertaining the life histories, habits and economy of *Œcanthus niveus* De Geer, *Œ. angustipennis* Fitch and *Œ. nigricornis* Walker, which are the most injurious species attacking bush and tree fruits in New York.

TREE CRICKETS AND THEIR WORK.

GENERAL CHARACTERS.

The tree crickets discussed in this bulletin belong to the genus *Œcanthus*[1] of the family Gryllidæ. They are orthopterons and are near relatives of such insects as grasshoppers, locusts, etc., and, as would be expected from such relationships, they have in their structures and in certain habits points in common with them. As implied in their popular name, the tree crickets exhibit arboreal habits, living principally on trees, shrubs, weeds and even low-lying plant growth. In addition to their preference of plants for their various activities they exhibit also marked differences in shape and color from the robust, dark-colored house and field crickets which are familiar to most readers. They are slender creatures, usually light green in color, and possess transparent wings and wing covers; the latter are in the case of the males very broad and when at rest lie

[1] This presumably means "flower-inhabiting" and is derived from the Greek words οἶκος, house, and ἄνθος, flower.

flat over the abdomen. The antennæ are delicate and threadlike, and are with some species from two to two and one-half times the length of the body. The first and second segments of these appendages are frequently ornamented with black markings, which are constant with the different species; and, as pointed out by Hart,[2] these may furnish important distinguishing characters. The tree crickets for the most part deposit their eggs preferably in the annual growth of plants, and during their early nymphal existence they show pronounced predaceous habits. As they approach maturity they display phytophagous and mycophagous tendencies, feeding on the floral organs of various plants as well as foliage and fruits of different sorts, and even minute fungi that may occur on bark or decaying vegetation.

DISTRIBUTION.

Representatives of the genus *Œcanthus* occur in southern and central Europe, southern Asia, the East Indies, Africa, North and South America, and one species is recorded as rare in Australia. Each geographical region has its distinct fauna and, with the present state of systematic knowledge, none of the species seem to have been influenced by commerce to become cosmopolitan in their distribution. One species only, *pellucens*, is found in Europe, and this occurs solely in the warmer latitudes. The American continent appears to be especially rich in the numbers of these insects, and according to Kirby[3] no less than sixteen species out of a total of twenty-seven species listed by him are recorded from this region. Of the species occurring in North America, none apparently are known to range farther north than southern Canada. From available records *niveus* is the most generally distributed of the species occurring in the United States, ranging from Massachusetts to the Pacific Coast and from the Province of Ontario on the north to as far as Mexico on the south. Such species as *nigricornis*, *quadripunctatus*, *angustipennis* and *latipennis* are common insects in the region east of the Rocky Mountains.

ECONOMIC IMPORTANCE.

The tree crickets derive their economic importance largely from their predatory habits, in subsisting upon other forms of insect life,

[2] C. A. Hart. *Ent. News*, 3:33. 1892.
[3] W. F. Kirby, Synonymic Catalog. of Orthoptera, 2:72–76. London, 1906.

and from their injurious work upon various cultivated crops. They are also suspected of acting as carriers of various plant diseases. Many writers upon these insects have commented upon their carnivorous tendencies, and from this standpoint alone some have concluded that the tree crickets are beneficial rather than inimical to the farmer. The fondness of various species of these insects for plant lice is well known, and when these occur in abundant numbers they constitute an important item in the diet of the crickets. Bruner[4] has noted the predaceous habits of *latipennis* and states that it feeds on saw-flies, leaf-hoppers and tingitids. Conspicuous constituents in the food of tree-inhabiting species, as *niveus* and *angustipennis*, are scale insects. An examination of the crop contents of a number of specimens of *niveus* from an apple orchard infested with the San Jose scale has revealed the presence of varying numbers of pygidia of this coccid which were intermingled with numerous fragments of plant tissues and bristles, pieces of chitin, etc., of larger insects. Unquestionably many other kinds of insects aside from those mentioned fall as prey to these crickets. The actual importance of tree crickets in this role deserves more careful consideration, but on the basis of our studies it appears that their beneficial services have, in the main, been over-rated because of their relatively small numbers in comparison with other groups of predaceous and parasitic insects.

Their status as depredators on cultivated plants is more clearly understood. One of the most injurious species is *nigricornis*, which may seriously damage raspberry plantations, and it is widely distributed. The injuries are due primarily to the slitting of the canes as a result of extensive oviposition, which weakens a stalk so that it dies or breaks at the point of the wounded area from the weight of the foliage or as a result of a strong wind. Certain species have attained some distinction because of their depredations on various fruits. Garman[5] has observed *niveus* and *angustipennis* feeding on ripening plums and peaches, and *latipennis* on grape clusters. The attacks of the latter species were considered especially injurious, as the rupturing of the epidermis of the fruits apparently facilitated the spread of black rot. Wounds in the other fruits also became centers of infection with brown rot. Saunders[6] of Canada has

[4] L. Bruner, Nebr. Exp. Sta. Bul. 14. 1890.
[5] H. Garman, Ky. Agr. Exp. Sta., Bul. 116.
[6] W. Saunders, Ont. Ent. Soc., Rept. for 1873. 1874.

likewise noted the destructive capacities of these insects in a similar role. Mally[7] of Cape Town, South Africa, states that an apparently indigenous species, *capensis* Sauss., has become quite troublesome in peach orchards because of the small, round, surface wounds in peaches especially grown for exportation. Tree crickets also feed on foliage of various plants, and in the case of tobacco they have been reported as causing damage of a more or less serious nature. McCarthy[8] states that in North Carolina *niveus* (*nigricornis?*) often damages tobacco in fields much infested by blackberry bushes. Metcalf[9] reports that in North Carolina a light greenish tree cricket eats round holes through the tobacco leaves, and states, also, that he has seen tobacco plants set in new ground, surrounded on all sides by heavy growth of blackberries, which were seriously damaged by both nymphs and adults. He says also that tree crickets do not ordinarily frequent tobacco fields that are removed from weeds and brush. In his memoir on "The Principal Insects of the Tobacco Plant," Dr. Howard[10] makes the statement that young tree crickets are occasionally found upon tobacco, eating the leaves to some slight extent. Both *niveus* and *angustipennis* have also been observed to feed on foliage of apple trees, but the consumption of leaf tissues appeared to be small and unimportant.

In considering the economy of tree crickets reference should also be made to their suspected role as vectors of plant diseases. Apparently the first writer to call attention to the activities of these insects in this capacity was Hopkins[11] of West Virginia who noted that the puncturing of bark by an unknown species of tree cricket often resulted in a blighted condition of apple wood. In New York there is seemingly a similar association between *niveus* and some infectious organism which results in diseased areas in the bark of apple trees, especially noticeable in orchards that are neglected or given little care. Detailed information dealing with the intimate relation of *niveus* to bark diseases is wanting and, although there is strong presumptive evidence, no conclusive experimental proof has so far been presented that this species actually serves as an agent in the transmission of such disorders of fruit trees.

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[7] C. W. Mally. Letter of Oct. 15, 1913.
[8] Gerald McCarthy, N. C. Agr. Exp. Sta. Bul. 78, p. 17. 1891.
[9] P. Metcalf. N. C. Dept. Agr. Special Bulletin, "Insect Enemies of Tobacco." pp. 64–65. 1909.
[10] L. O. Howard, U. S. Dept. Agr. Yearbook 1898, p. 143.
[11] A. D. Hopkins. W. Va. Exp. Sta. Bul. 50, p. 39, 1898.

GENERAL DESCRIPTIONS OF LIFE STAGES OF TREE CRICKETS.

Egg.— The eggs of the species belonging to the genus *Œcanthus* are elongate, cylindrical, and slightly curved. At the time of deposition they are semi-transparent, but later they grow more opaque and become slightly swollen. The cephalic end possesses a whitish opaque cap, which is covered with minute projections, arranged in spiral rows after the fashion of the scales of a pine cone. At the extreme base of the cap, only shallow rhombic depressions occur, but above the first few rows short projections appear between the indentations and gradually increase in size in each successive row. The entire surface of the egg, exclusive of the cap, is etched with what appears to be very minute, cross-hatched scratches. The number and size of the spicules vary considerably with different species and are useful characters for distinguishing the eggs of certain of the crickets.

Nymph.— First instar (Plate XXVIII, fig. 1): The newly-hatched tree crickets are pale and delicate creatures, with slender legs and long antennæ. After feeding, the size of the abdomen is increased and the contents of the alimentary canal show through the body wall, giving the insects a slightly darker color and more robust appearance. The pronotum, when viewed from above, is rectangular in form, a little wider than long, with sides broadly rounded and margined with a scant fringe of small bristles. The meso- and metanotum are each about equal to the pronotum in width and a little more than half as long. The hind margins of both bear a few small bristles which are directed posteriorly. The cerci are conical, about four times as long as width of base. This stage may be distinguished from the succeeding instar by two characters: (1) The antennæ have thirty-four segments. (2) The sides of the meso- and metanotum do not project, and extend downward scarcely as far as do the sides of the pronotum. (Fig. 26, a.)

Second instar (Plate XXIX, fig. 2): This stage differs but little from the preceding instar. The side margins of the pronotum flare outward slightly. The metanotum is a little longer than the mesonotum. Both extend down the sides as far or slightly farther than the pronotum; the side margins are free and lap over the pleura. (Fig. 26, b.) The number of antennal segments is about double that of the preceding stage. The females show the anlage of the ovipositor

in the form of two small, rounded projections on the ventral side of both the eighth and ninth abdominal segments. They are close together and are most pronounced at the posterior margins of the segments.

Third instar (Plate XXVIII, fig. 3): The pronotum is a trifle longer than broad; marginal bristles very numerous. The metanotum is about one and one-half times as long as the mesonotum. The sides of both bear rudimentary wing pads reaching nearly to the middle coxæ. (Fig. 26, c.) The cerci are noticeably longer, about five times as long as width of base. The antennal segments are relatively shorter than in preceding stages and the normal number of segments is increased to nearly one hundred. The anlage of the ovipositor consists of four backward-pointing papillæ. The front pair is smaller and lies in contact with the lower surface of the hind pair.

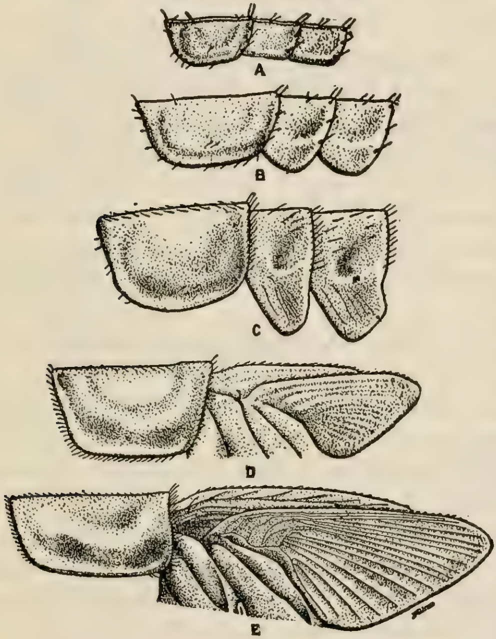


Fig. 26.— Thoracic Segments of Nymphs.

Fourth instar (Plate XXVIII, fig. 4): The wing pads, in comparison with earlier instars, are greatly increased in size and instead of projecting downward are folded back over the meso- and metanotum. (Fig. 26, d.) The bases of the first pair are covered by the hind margin of the pronotum and their tips reach the first abdominal segment. The second wing pad covers the lower part of the first and reaches to the middle of the second abdominal segment. The four components of the ovipositor are longer than before and form a compact body, extending a trifle beyond the tip of the abdomen. The sterna of the eighth and ninth segments are reduced and almost

completely taken up by their appendages. The sternum of the seventh segment is longer and touches the base of the ovipositor.

Fifth instar (Plate XXVIII, fig. 5): The first pair of wing pads reaches to the second abdominal segment and the second pair reaches to the third or fourth segment. (Fig. 26, e.) Cerci and ovipositor are twice as long as in preceding stage. Front tibiæ have a swelling near the proximal end, at which point in the leg of the adult insect a tympanum occurs.

Adult (Plate XXVIII, fig. 6).— Body slender. Long axis of head in life nearly horizontal. Pronotum slightly elongated; disk narrowed in front; sides nearly vertical at hind edge, flaring outward in front part. Abdomen composed of ten segments, including the last which bears the cerci and anus. First segment much reduced ventrally. Antennæ filiform; over twice the length of body. Legs slender; hind femora a little thickened. Hind tibiæ with a double row of teeth on posterior side, intermixed on distal half with longer spines; with three pairs of spurs at the tip. Anterior tibiæ with a tympanum near the base.

The hind wings of both sexes are folded and generally extend beyond the tip of the fore wings.

Males have the forewings much broader than body. A longitudinal fold occurs about one-third way from the costal margin; the inner two-thirds lies horizontally over the back and the remainder is deflexed toward the sides.

The fore wings of the female are regularly reticulated, much narrower than those of the male, and are wrapped closely around the body. A longitudinal bend of about ninety degrees is located about half way between the two margins.

NATURAL ENEMIES.

The tree crickets of the genus *Œcanthus* are, throughout their normal range of distribution, subject to the attacks of a number of natural enemies. The most common and efficient of these are egg parasites, of which there are eight known species. These are hymenopterons, three species belonging to the Chalcidoidea and five species to the Proctotrypoidea. In view of the confusion which has existed in regard to the identity of the different species of tree crickets, we cannot feel sure that the hosts of the parasites have been correctly recorded. Judging from the statements that accompany the descrip-

tions of these hymenopterons it seems probable that most of them were reared from eggs of *nigricornis* or possibly *quadripunctatus*. The following is an annotated list of these insects:

1. *Macrorileya œcanthi*. Ashmead.
   Ashmead, Carnegie Mus. Mem. I, No. 4 (Serial No. 25). 1904.
   Rileya sp.
   Bruner, Nebr. Agr. Exp. Sta. Bul. 14: 126. 1890.
   Bred from *Œcanthus* eggs in twigs. The species of tree cricket was not named, but it was probably *nigricornis* or *latipennis*.
2. *Anastatus* (*Antigaster*) *mirabilis*. Walsh.
   Ashmead, *Ins. Life* 7: 245. 1894.
   "Captured in act of ovipositing in eggs of *fasciatus*" (*nigricornis*).
3. *Polynema bifasciatipenne*. Girault.
   Girault, *Jour. N. Y. Ent. Soc.* 18: 254. 1910.
   Recorded by several writers from eggs of *Œcanthus* in raspberry, resin weed, *Grindelia*, etc. The eggs were probably those of *nigricornis* in all cases.
   We have reared this species from eggs of *nigricornis* in raspberry.
4. *Teleas* (?)
   Ayer, *Bost. Soc. Nat. His.* 3: No. 8. 1884.
   Review *Amer. Nat.* 18: 537. 1884.
   Recorded as a parasite of *niveus*, but since the eggs were taken from the pith of elder they were probably those of *nigricornis*.
5. *Caloteleia* sp.
   Bruner, Nebr. Agr. Exp. Sta. Bul. 14: 126. 1890.
   Bred from twigs containing eggs of *Œcanthus*.
6. *Baryconus œcanthi*. Riley.
   Riley & Howard, *Ins. Life*, 4: 124. 1891.
   Eggs of *niveus* (probably *nigricornis*), Nebr.
7. *Cacus œcanthi* Riley.
   Riley & Howard, *Ins. Life*, 4: 124. 1891.
   Eggs of *niveus* (probably *nigricornis*), Kans. and Ind.
   Eggs of *latipennis*. Mo.
   We have reared this species from eggs of *nigricornis* in raspberry and have the larval and pupal stages.
8. *Idris* sp.
   Webster, *Ins. Life*, 3: 345. 1891.
   Recorded from eggs of *niveus* (probably *nigricornis*) in raspberry canes.

An adult of *Polynema bifasciatipenne* (Fig. 27) was found on September 17, 1910, running about a portion of a raspberry cane in which eggs of *nigricornis* had been deposited. On September 26 a small larva which was a little over 1 mm. long was found attached to an egg of this species of cricket taken from the same planting. It was thought that this was a larva of *Polynema* but we were unable to rear the insect to the adult stage.

In 1912, from a box containing raspberry canes with eggs of *nigricornis*, an adult *bifasciatipenne* emerged on August 24, another on September 3, and a third specimen on September 4. The adults are slender insects about 2 mm. long, with long legs and peduncled abdomen. The color is yellowish brown. The fore wings are broad

and have a narrow dark band near the base, a broad one across the middle, and a broad one near the tip. The hind wings are extremely narrow. The antennæ of the female are about half the length of body and are 9-jointed, the last joint being the largest. The antennæ of the male are filiform, longer than the body and are 13-jointed. (Fig. 27, a.)

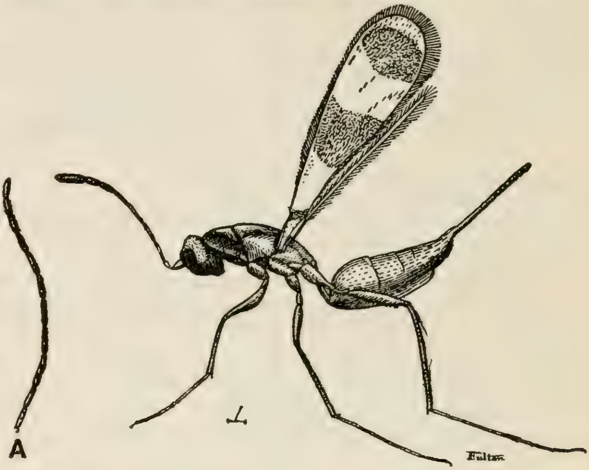


Fig. 27.— Adult Female of *Polynema bifasciatipenne.* A, Antenna of male.

A number of eggs of *nigricornis* were examined on July 22, 1912, and some of them which remained unhatched contained larvæ of a parasite which proved to be *Cacus œcanthi.* The larvæ were about full grown and measured 2.3 mm. in length by .5 mm. in diameter. (Fig. 28, a.) The body is made up of eleven segments, each of which, except the last, has two rounded protuberances on each side, while segments 2 to 7 inclusive have a pair of small but prominent protuberances on the dorsal side. The margins of the segments are elevated, especially on the sides of the body. The color is generally a translucent white, but segments 2 to 6 inclusive appear yellowish, due apparently to some internal organ.

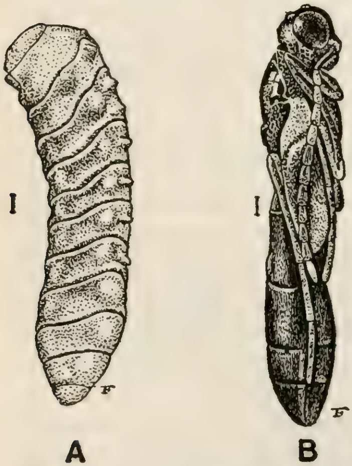


Fig. 28.— *Cacus œcanthi:* a, larva; b, pupa.

The pupæ were formed near the end of July. (Fig. 28, b.) They were white at first but later turned black and had all the characters of the adult. On September 5,

1912, three adults emerged in the box containing eggs of *nigricornis* and on the following day one more appeared. (Fig. 29.) The adult is 2.3 mm. in length. The body is entirely black except the legs which are dark brown. The abdomen is 6-jointed, slender, flattened, and club-shaped. The front wings have the submarginal vein meeting the costa just beyond the middle; the stigmal vein is curved, oblique, and terminates in a knob. Both sexes have 12-jointed antennæ; in the male they are filiform (Fig. 29, a); in the female the first joint or scape is very large; the second, third and fourth slender, the fifth and sixth transverse, and the remaining six segments form a compact club.

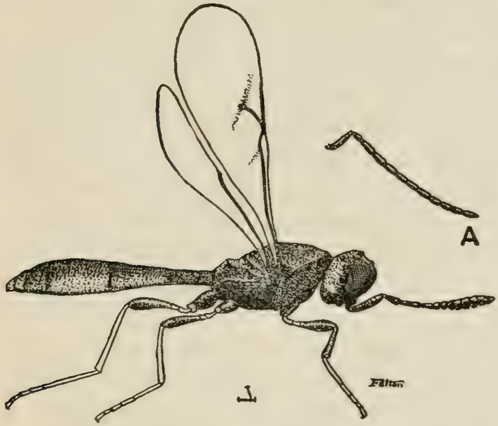


FIG. 29.—ADULT FEMALE OF *Cacus æcanthi:* a, antenna of male.

A dipterous parasite.— On August 29, 1912, a puparium of some dipterous insect was found in a bottle with a sickly, yellowish-looking specimen of *quadripunctatus* in the fifth nymphal instar, which was still alive. By dissecting a number of specimens of tree crickets we found one which contained a larva of the same parasite. This larva was large and ovoid in shape, and of a pale yellowish color. It occupied the abdominal cavity above the alimentary canal and below the fat body. The cricket was alive when cut open, but it was of an abnormal yellowish color and the abdomen was distended. The parasitic larva pupated but we were unable to rear adults from the two puparia.

Mermis sp. In our rearings of tree crickets we have occasionally noticed examples of parasitism with hairworms. Individuals that were parasitized became quite sluggish in their movements during the last stages of life and were more or less discolored. The tip of the abdomen was generally blackish and there were also indications of a dark-colored discharge from the anus. Nymphs of the fourth

and fifth instars seemed to be most affected, and only one hairworm was observed to make its escape from each insect, which was accomplished through the anus. The extent to which hairworms occur in tree crickets seems to show considerable variation from year to year, and was greatest during July and August in 1908 and 1909. In subsequent years they have been observed much less frequently. As orthoptera generally are subject to parasitism by these creatures, specimens of the hairworms were sent for identification to Dr. B. H. Ransom of the U. S. Bureau of Animal Industry who reported that they were larvæ of a *Mermis* sp. Because of their immature condition it was stated that it was not possible to determine definitely if they were the same species as exist in other kinds of crickets and grasshoppers.

Stalk-boring insects.— Eggs of *nigricornis* and *quadripunctatus* are sometimes destroyed by various species of stalk-borers. These latter are not true parasites, but the effect of their operations, in tunneling through the central pith of weeds and other plants and feeding upon it, is to hollow out stems and stalks, which effectually disposes of any eggs of a tree cricket that happen to be in the path of the boring insect.

KEY TO THE SPECIES OF *Œcanthus* FOUND IN NEW YORK STATE.

A Basal segment of antennae with a swelling on the front and inner side. First and second segments each with a single black mark.

B Basal antennal segment with a round black spot. (Fig. 30, a.) *niveus* De Geer

BB Basal antennal segment with a J-shaped black mark. (Fig. 30, b.) *angustipennis* Fitch

BBB Basal antennal segment with a straight club-shaped black mark. *exclamationis* Davis

AA Basal antennal segment without a swelling on the front and inner side. First and second antennal segments each with two black marks or entirely black. Tegmina of male 5 mm. or less in width.

B Head and thorax pale yellowish-green or black or marked with both colors.

C First antennal segment with a narrow black line along inner edge and a black spot near the distal end. Body entirely pale yellowish-green. *quadripunctatus* Beut.

CC First antennal segment with black markings similar to above, but broader and usually confluent, sometimes covering the whole segment. Head and thorax often with three longitudinal black stripes; ventral side of abdomen always solid black in life. (Fig. 30, c, d.) *nigricornis* Walker

BB Head, thorax and antennae reddish brown. Wings in life with conspicuous green veins. Marks on basal antennal segment broad but seldom confluent. *pini* Beut.

AAA Basal antennal segment without a swelling on the front and inner side. Basal portion of antenna red, unmarked with black. Tegmina of male about 8 mm. wide. *latipennis* Riley

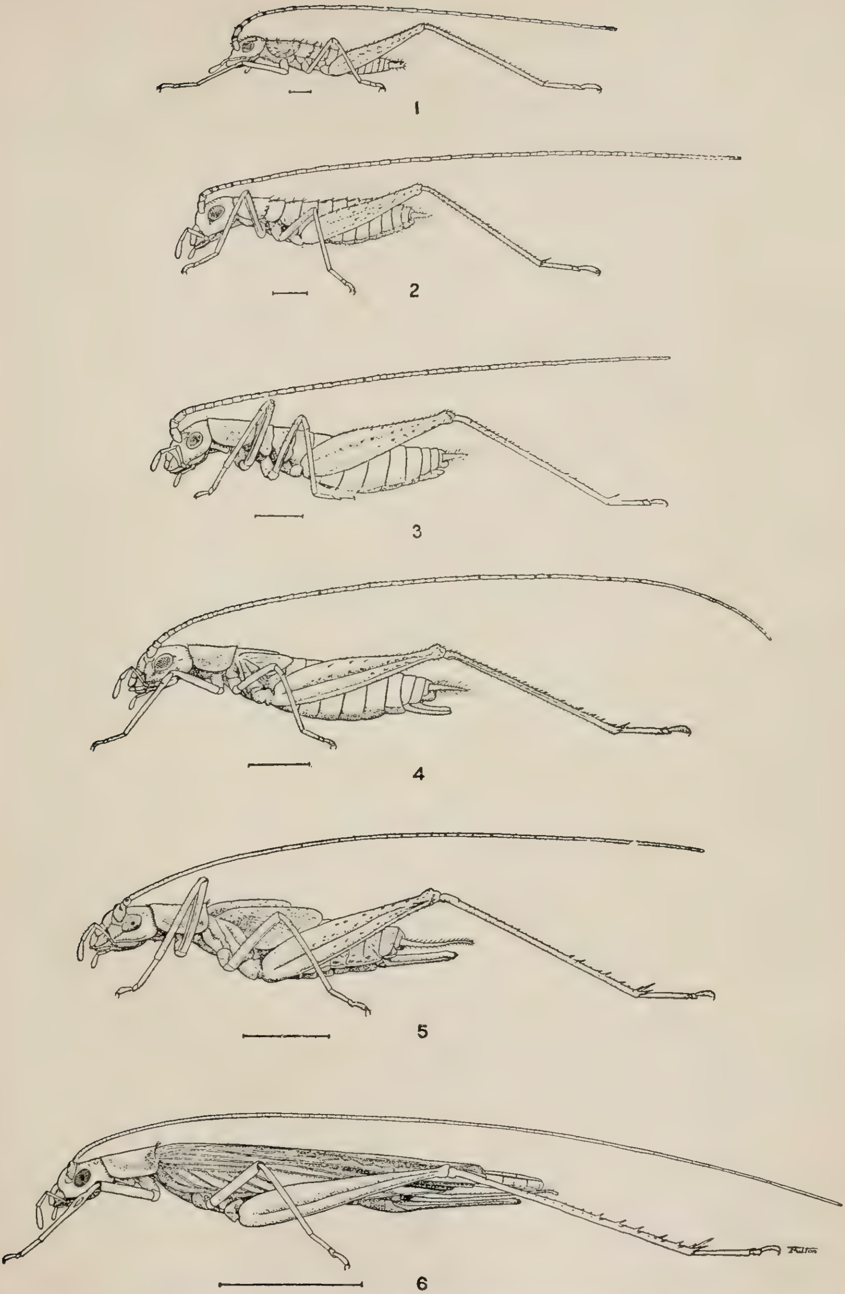


Plate XXVIII.—Life Stages of the Snowy Tree Cricket (*Œ. niveus*): Nymphal Instars and Adult.

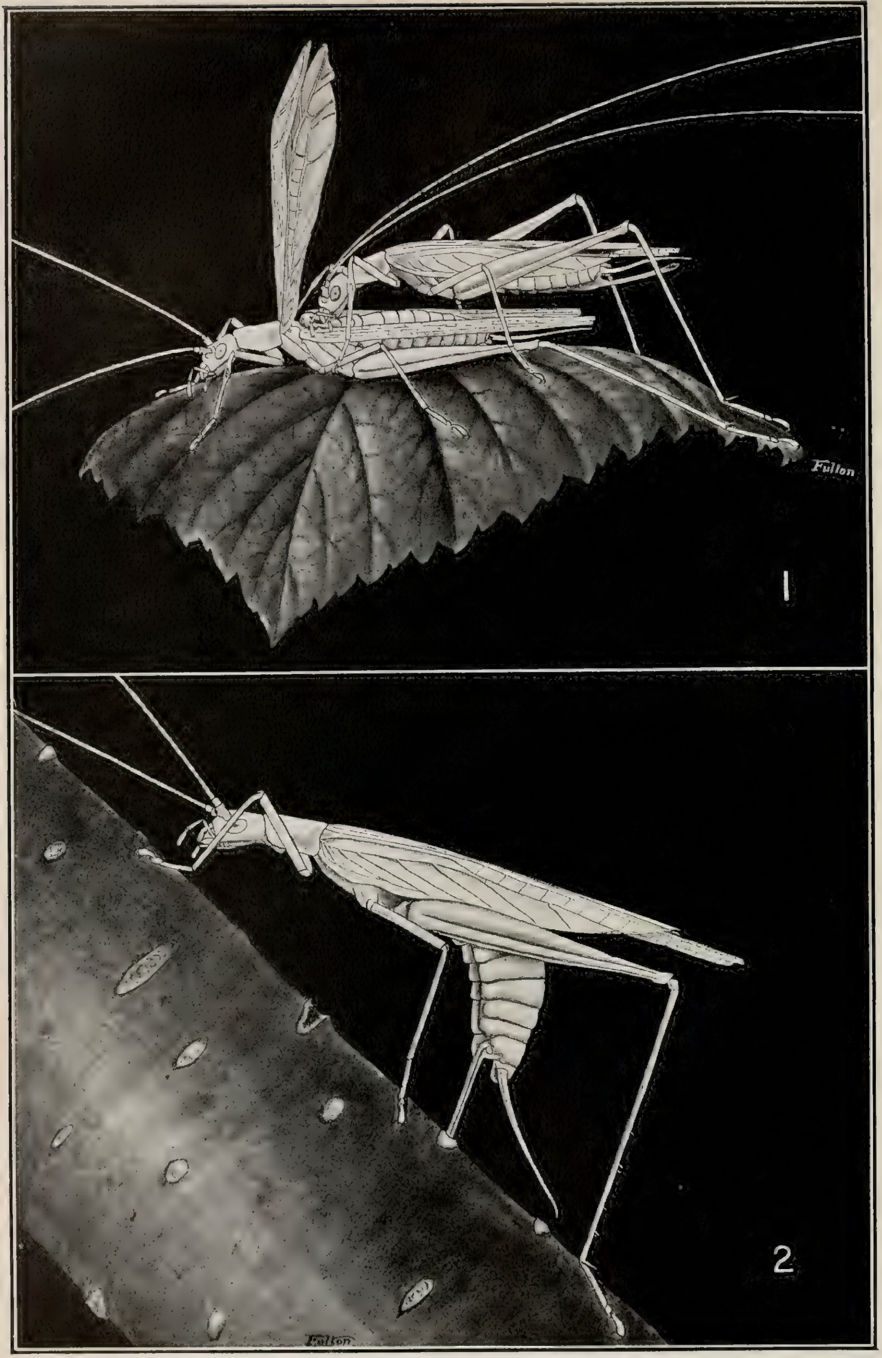


Plate XXIX.—Snowy Tree Cricket (*Œ. niveus*).
1, Female feeding on thoracic gland of male; 2, Characteristic posture of female in act of ovipositing.

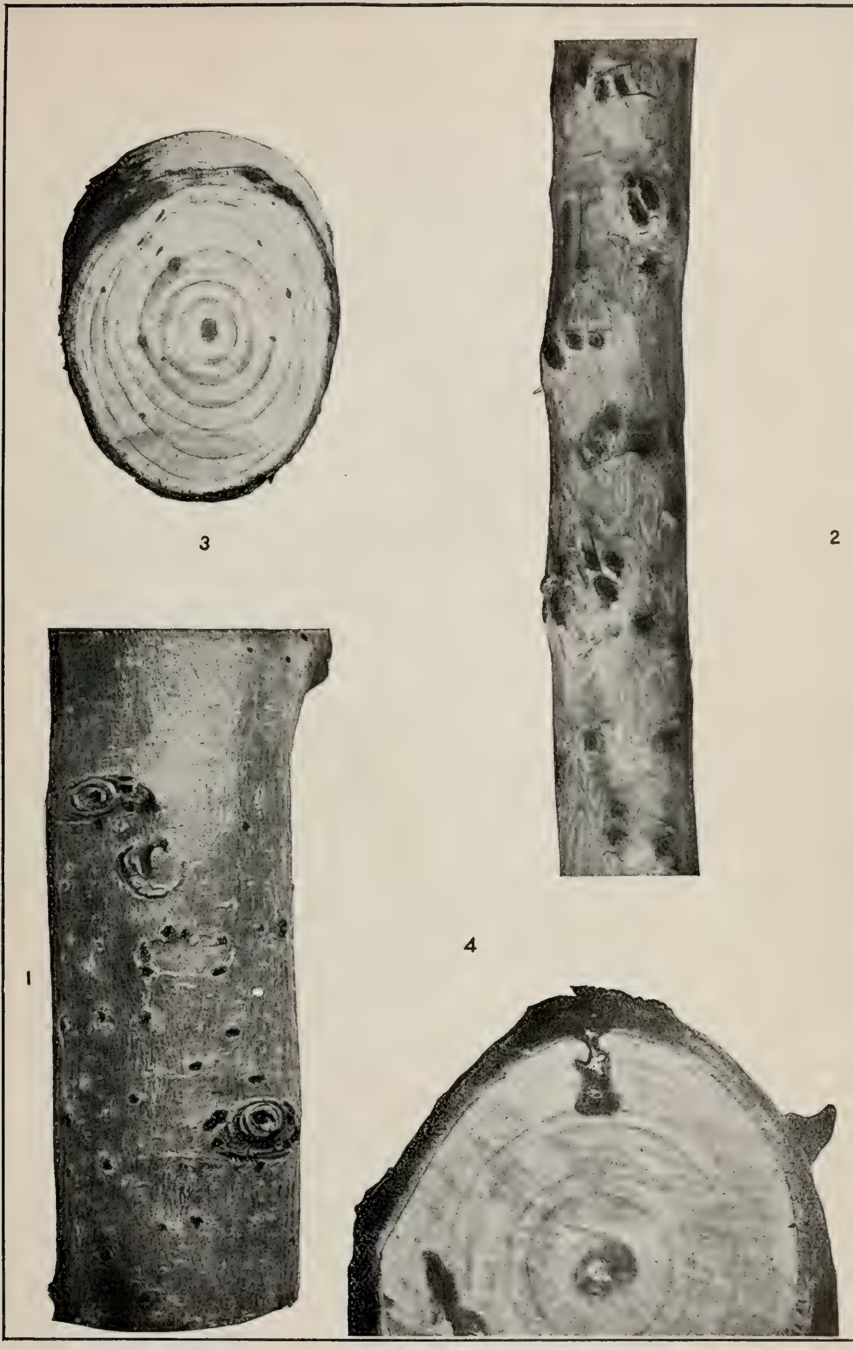


Plate XXX.—The Snowy Tree Cricket (*Œ. niveus*).
1, Normal scars on apple; 2, oviposition injuries under bark; 3 and 4, cross sections showing scars and diseased areas.

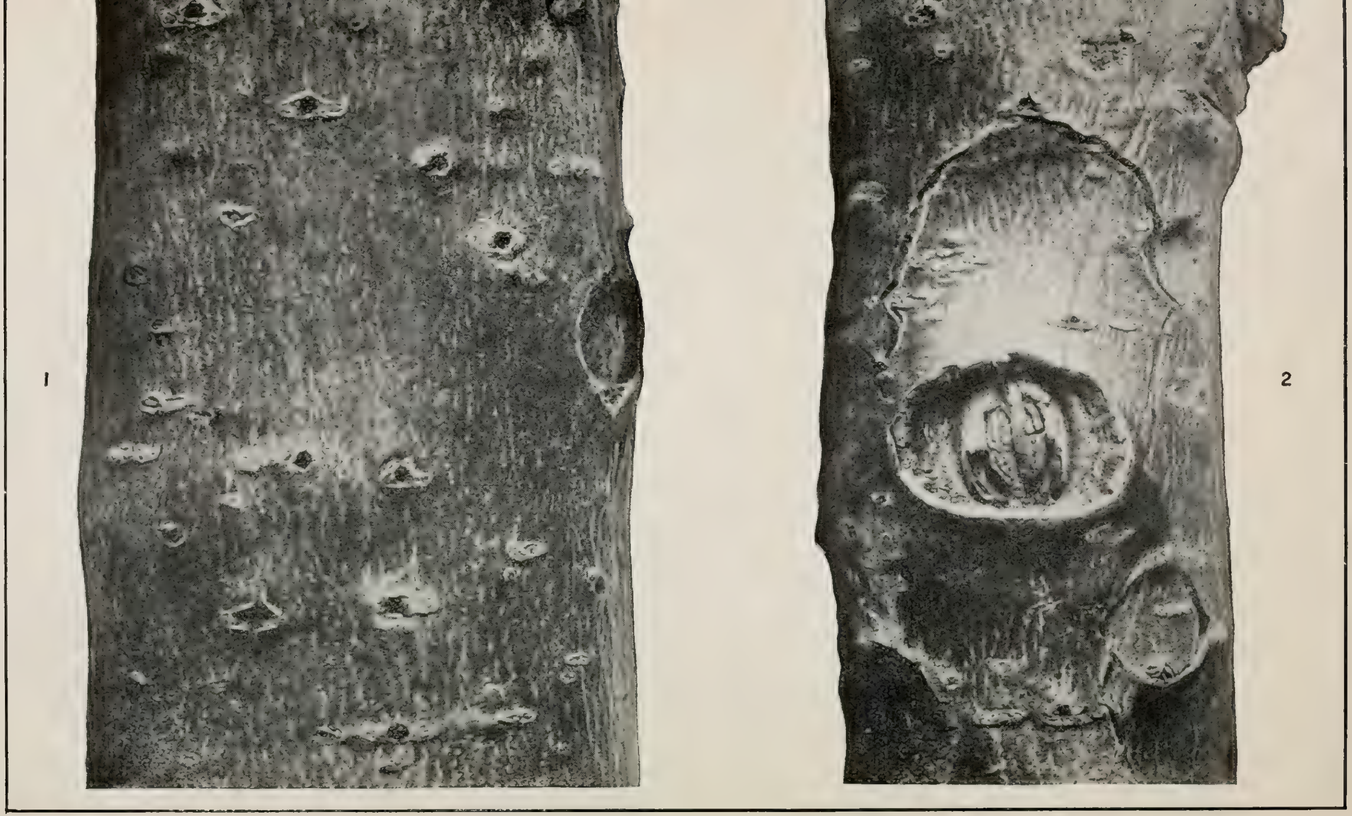


PLATE XXXI.—SNOWY TREE CRICKET (*Œ. niveus*).

1, Oviposition punctures in apple lenticels (enlarged); 2, old canker about cricket puncture and subsequent extension of diseased area.

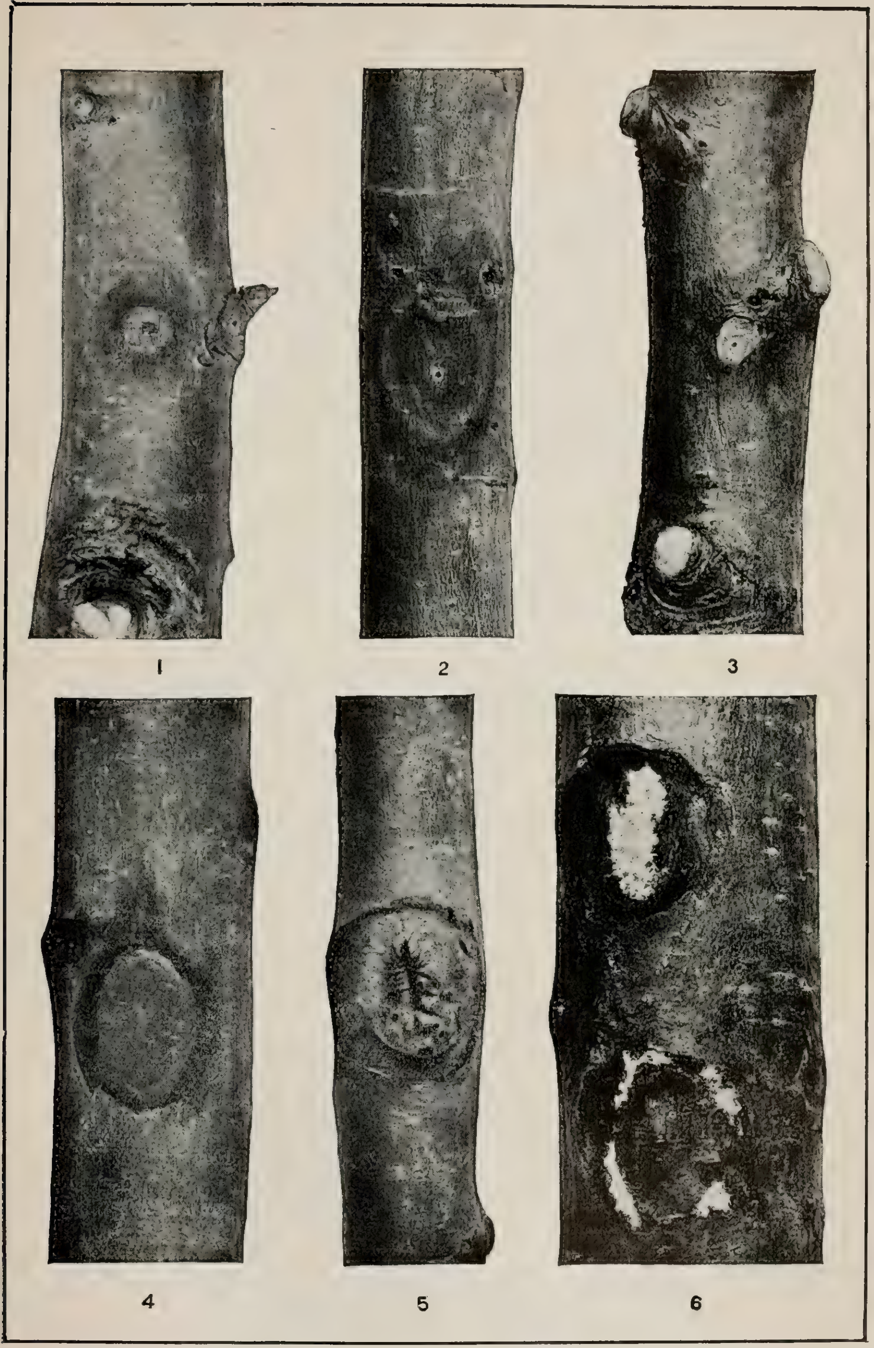
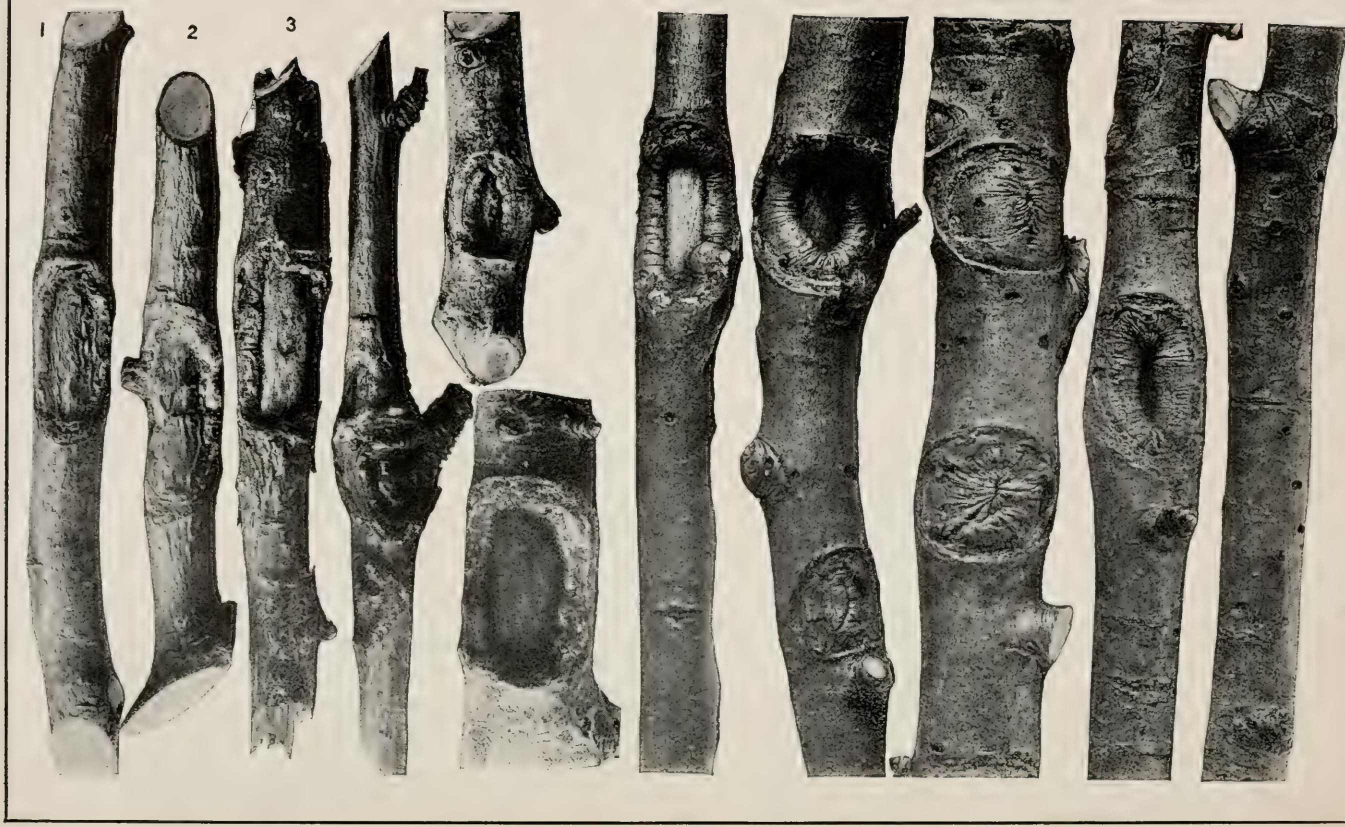


Plate XXXII.—Snowy Tree Cricket (*Œ. niveus*).

1, Young canker showing exudation; 2, more advanced stage; 3, separation of bark about diseased area; 4 and 5, partially and normally healed cankers; 6, woolly aphis in cankers.



(Photograph by A. D. Hopkins.)

Plate XXXIII.—Disorders of Various Kinds Following Oviposition by Tree Crickets in Apple Wood.
In 2 and 3 note V-shaped oviposition scars by *angustipennis*.

PLATE XXXIV.—STRIPED TREE CRICKET (*Œ. nigricornis*).

1, 2, 3, Oviposition in raspberry; 4, bark removed showing holes in cane; 5, slitting of canes following oviposition.

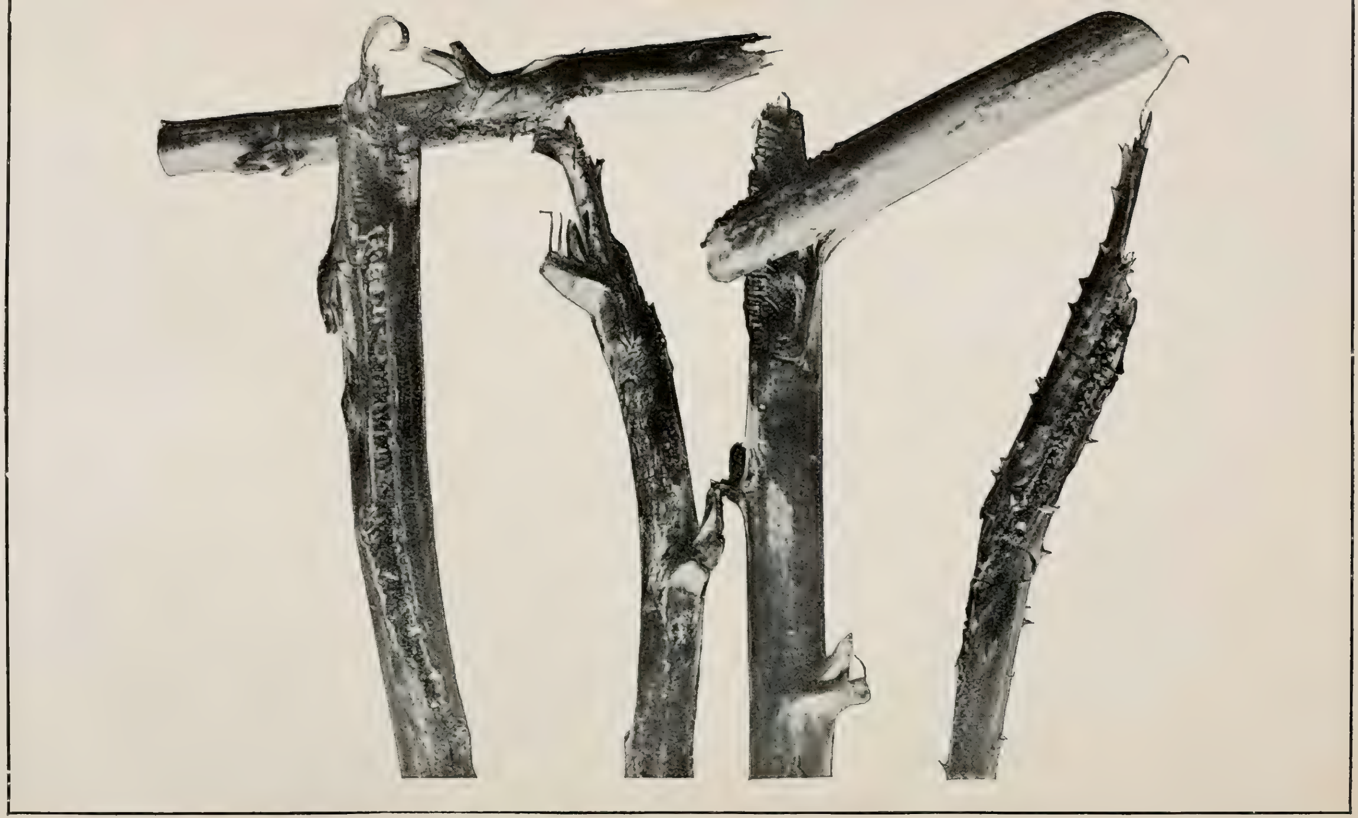


Plate XXXV.—Striped Tree Cricket (*Œ. nigricornis*).
Breaking of raspberry canes due to extensive oviposition.

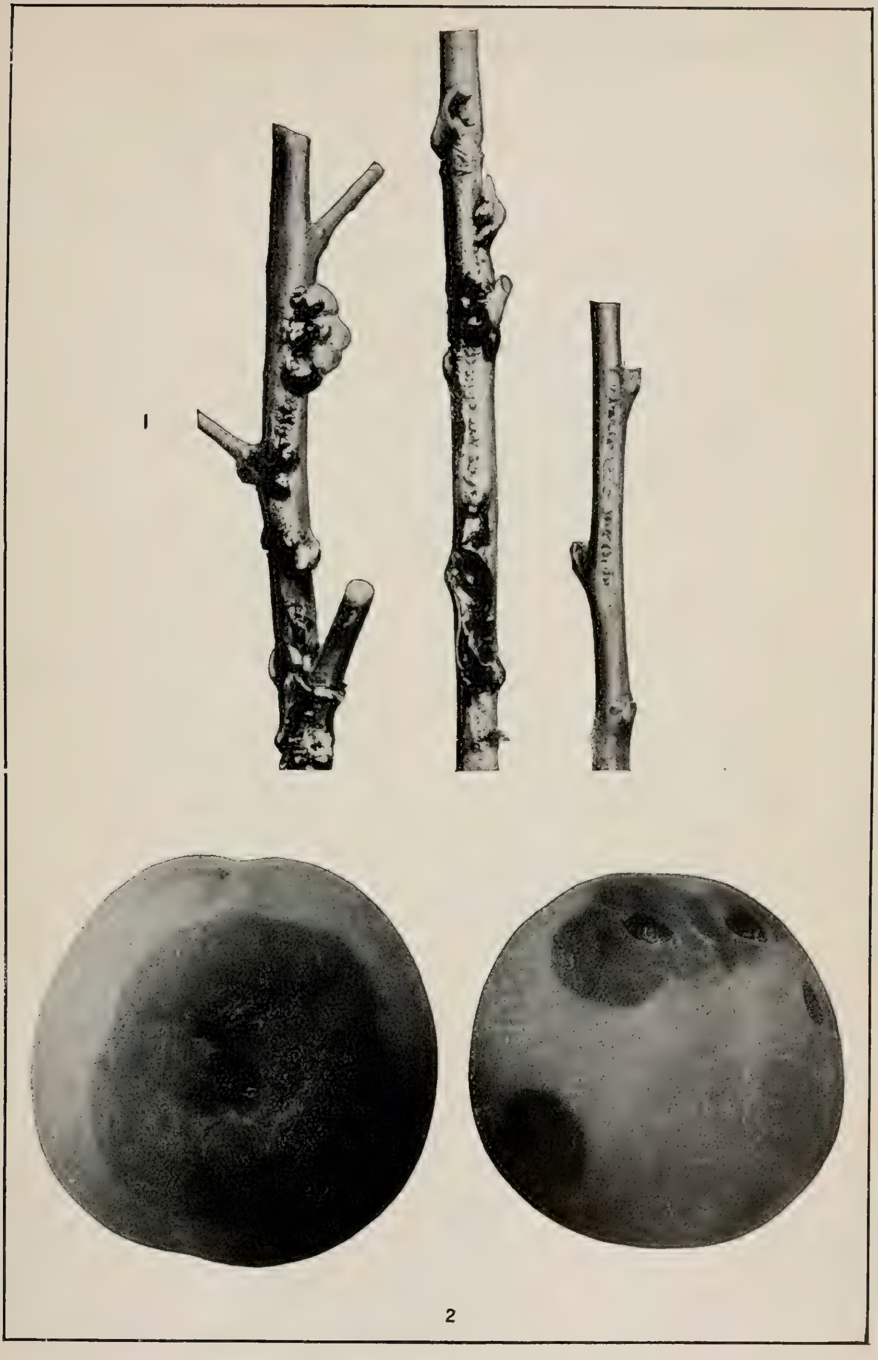


PLATE XXXVI.— TREE CRICKET INJURIES.

1, Oviposition by *nigricornis* in peach wood; 2, brown-rot infection of peaches following feeding, photographed by H. Garman.

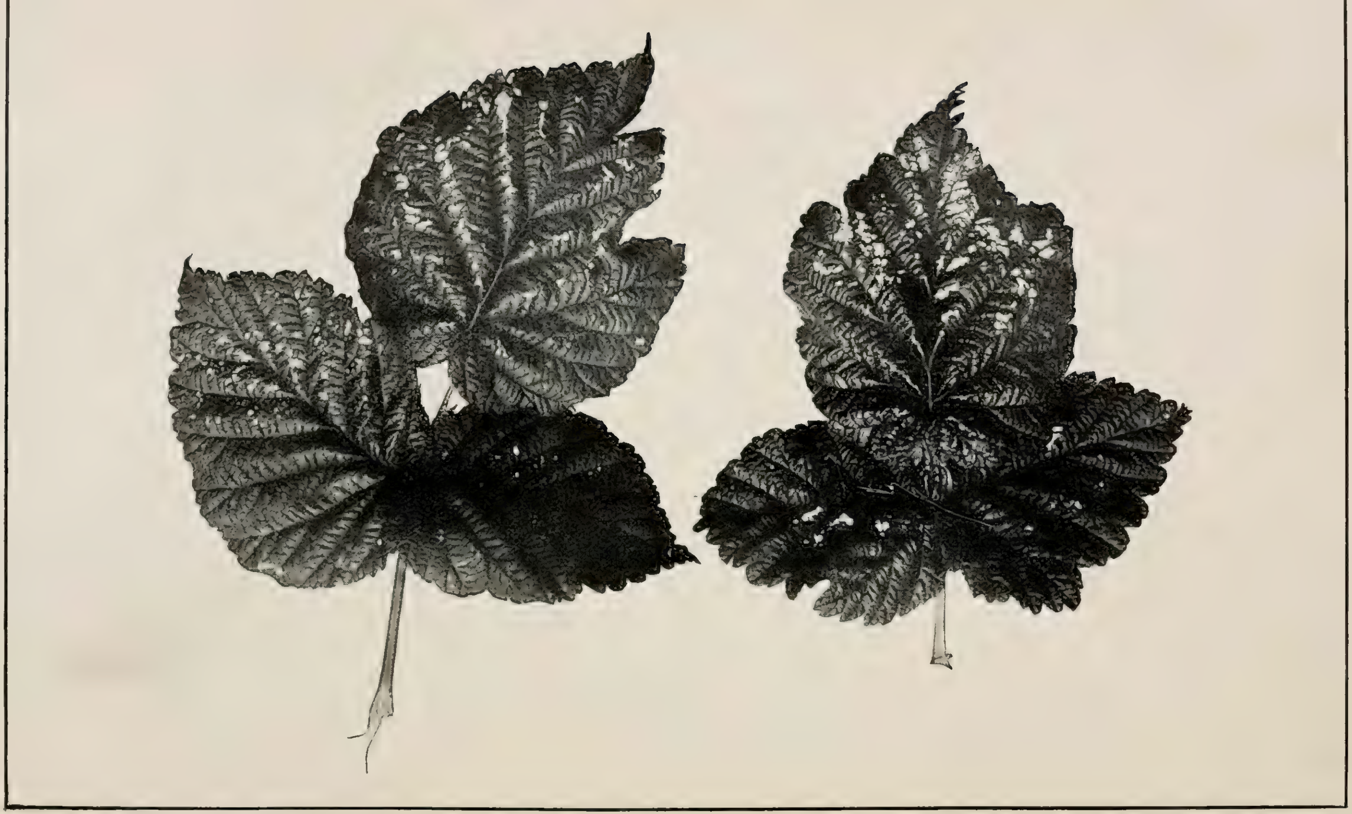


Plate XXXVII.— Striped Tree Cricket.— (*Œ. nigricornis*).
Characteristic feeding on raspberry leaves.

STUDIES ON TREE CRICKETS OF BUSH AND TREE FRUITS.

THE SNOWY TREE CRICKET.

Œcanthus niveus De Geer[1]

HISTORICAL NOTES AND SYNONYMY.

This insect is one of the most common tree crickets as well as an important species. While its status has been clearly established in systematic literature, strangely enough it has been long confused in economic writings with *nigricornis*. Because of its mistaken identity *niveus* has generally been regarded as the author of serious injuries to raspberry, which really are the work of the latter species. The error arose from the failure of early economic workers to dis-

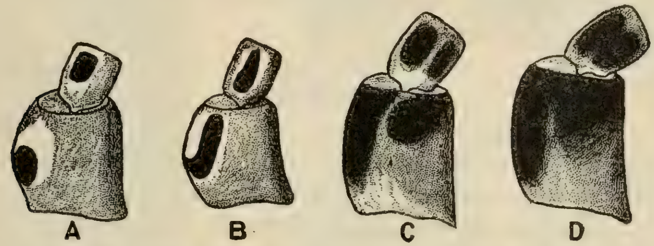


Fig. 30.— Basal Antennal Segments of Tree Crickets.
a, *Niveus;* b, *angustipennis;* c, *nigricornis*, light form; d, *nigricornis*, dark form.

tinguish the two crickets. Following his description of *niveus* Walsh[2] says " that varieties occur in both sexes with legs and antennæ almost entirely black " — characters which clearly designate *nigricornis*, while Riley[3] in an early discussion of the same species states " that some specimens have a blackish shade." Later Riley[4] says that he considers *fasciatus* (*nigricornis*) a dark and rather well-marked variety of *niveus*, and in this article makes the same statement about *nigricornis*, which as a matter of fact is synonymous with the above *fasciatus*. Because the identities of these crickets were not clearly understood, there has been more or less confusion in subsequent literature as to the habits of these insects, which still persists, although to a much less degree than formerly.

[1] First described as *Gryllus niveus* by De Geer. Memoir pour servir a l'historie des insectes. Orthoptera, 3: pp. 399–554. 1773.
[2] Walsh, B. D. *Pract. Ent.* 2: 54. 1867.
[3] Riley, C. V. 1st Rpt. Insects of Mo. 138. 1869.
[4] Riley, C. V. Sup. to 9 Rpts. on Insects of Mo. 60–61. 1881.

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A hint as to the true nature of *niveus* was given in a letter to the editor of the *Canadian Entomologist* in 1886 from E. W. Allis[5] of Michigan who states that he has "taken *niveus* entirely about apple and hardwood, and *fasciatus* (*nigricornis*) about raspberries and certain woody weeds. They are more common than *niveus* here and very distinct." Packard[6] describes the insect as "boring into the corky bark of the elm in the southern states, inserting its eggs irregularly, not in a regular series as when it oviposits in blackberry, raspberry and grape." As regards the elm, the eggs were probably those of *niveus*, while in case of the latter plants the oviposition was unquestionably by *nigricornis*. Within recent years these crickets have been more closely studied by a number of workers, notably Houghton[7] of Delaware, whose work, with our own, has no longer left any doubt as to the true character of the egg-laying habits of the two species.

DISTRIBUTION.

This species ranges all over the State of New York with the exception of forested regions in the northeastern part. It has been recorded in literature from the following states: Massachusetts (Faxon), Connecticut (Walden), New Jersey (Davis), Ontario (Walker), Georgia (Allard), Illinois (Forbes), Kentucky (Garman), Minnesota (Lugger), Kansas (Tucker), Nebraska (Bruner), Michigan (Allis), Cuernavaca, Morelos, Mexico (Rehn), Cuba (Kirby). From specimens examined we can record its distribution in the following states: Colorado and Utah (Titus), Ohio (Kostir), New Jersey, North Carolina, Connecticut (Amer. Mus.), California (Doane); Maine, one specimen (Patch), Cuba (Cardin). From correspondence we have obtained other records as follows: Texas (Newell), North Carolina (Beutenmüller), California and Washington (Melander).

DESCRIPTION OF LIFE STAGES.

Egg (Fig. 31, c).— The egg is about one-ninth of an inch long and from one-sixth to one-fourth as wide. The color is dull white, often with a slight yellowish tinge. The cap (Fig. 31, d) is a little narrower than the main body; its sides are parallel and the end is broadly rounded. In color it is opaque white, but is often stained a reddish color by the bark. The projections on the cap (Fig. 31, e) are long and finger-shaped,

[5] Allis, E. W. *Can. Ent.* 18: 79. 1886.

[6] Packard, A. S. 5th Rpt. Ent. Com. Forest Insects, p. 230. 1890.

[7] C. O. Houghton. *Ent. News*, 15: 57–61 (1904), and *Can. Ent.* 41: 113–115 (1909).

having a uniform thickness of about .009 mm. from base to tip, and a length of .020 to .025 mm.

The average measurements of forty specimens of eggs are as follows: length 2.83 mm.; greatest width, .62 mm.; length of cap, .51 mm.; width of cap, .51 mm.

Nymph.— First instar (Plate XXVIII, fig. 1): Color white. Top of head with two rows of ten to fifteen small bristles, directed anteriorly and each with a small black spot at the base. There is a short black line extending backward from the upper edge of each eye and one or two pairs of brownish transverse spots between the eyes. The pronotum, and sometimes the meso- and metanotum, have a pair of longitudinal brownish stripes situated close to the median line. Basal segment of antenna with a small black spot on the inner side and a brownish spot on the posterior side; second segment with a black transverse line on the inner side; third, fourth, sixth and ninth segments with a narrow black ring at apex; each succeeding segment with faint gray

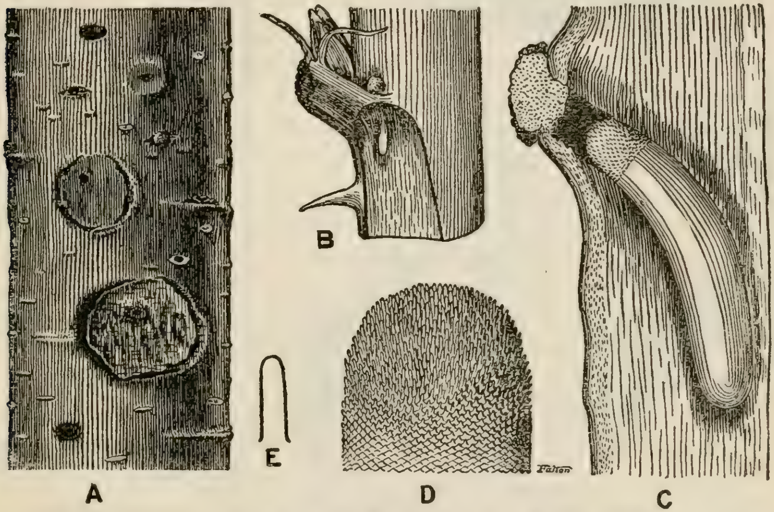

FIG. 31.— SNOWY TREE CRICKET.
a, Egg punctures and cankers in apple wood, ($\times 1\frac{1}{2}$); b, egg in raspberry ($\times 2\frac{1}{2}$); c, egg in apple bark ($\times$ 15); d, egg cap ($\times$ 50); e, spicule of egg cap ($\times$ 500).

annulation at tip. Hind tibiæ with black spots at the base of the small bristles, especially prominent on the outer and upper sides. Length about 3 mm. Antennæ 6.3 to 7.5 mm.

Second instar (Plate XXVIII, fig. 2): Ground color of abdomen transparent greenish white with two rows of pure white blotches on each side of median line. Basal segment of antenna with a round black spot on the front and inner side, and the second segment with a similar spot on the front side and a transverse dash on inner side. Outer part of antennæ with gray annulations on alternate segments. Length 4.5 to 5 mm. Antennæ 10.7 mm.

Third instar (Plate XXVIII, fig. 3): General color greenish white. Abdomen with several rows of irregular opaque white blotches on each side of median line. The brownish markings on the head and thorax are very faint. Black spot on first segment of antenna on a white prominence. Length 6 to 7 mm. Antennæ 13 mm.

Fourth instar (Plate XXVIII, fig. 4): Coloration practically the same as in the preceding stage. Length 8.5 to 9.5 mm. Antennæ 16 mm.

Fifth instar (Plate XXVIII, fig. 5): Color pale yellowish green. Segments of abdomen with a fairly regular pattern of roundish white blotches; a small one on front and one on hind margin on median line; larger blotches on each side are arranged alternately near the front and hind margins. Outer side of hind femur with numerous black spots extending over the distal two-thirds or four-fifths. Antennæ marked similar to adult. Length 11 to 12 mm. Antennæ 23 mm.

Adult (Plate XXVIII, fig. 6): Moderately slender. Pronotum as broad as long. Color very pale green. Top of head between eyes and antennæ orange yellow; occipital area with longitudinal transparent greenish blotches separated by white lines. Wings transparent, with a slight greenish tinge; veins more or less colored with yellowish

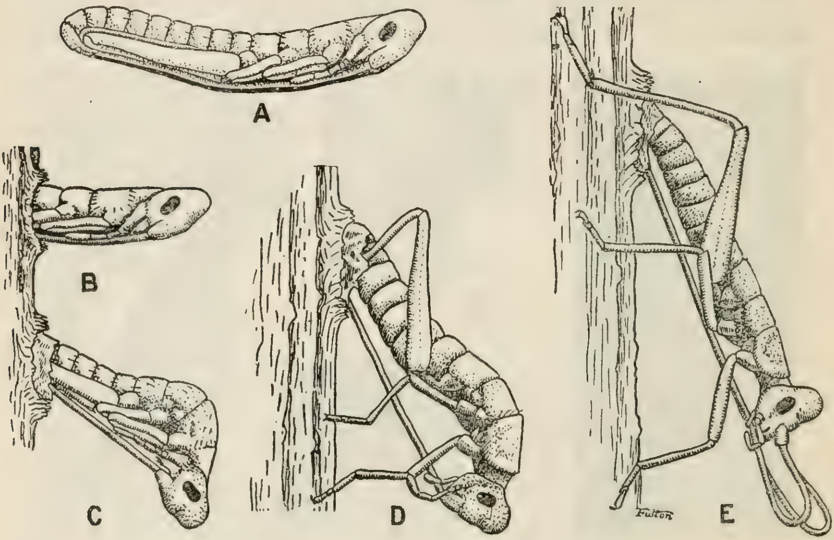

FIG. 32.— HATCHING OF TREE CRICKETS.
a, Position of embryo in egg. b, c, d, e, Successive stages in emergence of nymph.
(Drawings made from *Œ. quadripunctatus.*)

green. Forewings of male very broad. Antennæ white, with gray annulations in the outer part at intervals of about four segments. First segment is pale orange yellow on all parts except the large swelling on the front and inner side which is white and has a conspicuous round black spot in the center. (Fig. 30, a.) The second segment is white with a similar spot. Length to end of abdomen 14 mm. Forewing of male 13–14 mm. x 6 mm. Forewing of female 12–13 mm.

HATCHING OF EGGS AND TIME OF APPEARANCE OF NYMPHS.

Before hatching, the egg becomes swollen, due to internal pressure. The end of the cap then breaks off and the embryo slips out. When it first appears the body is nearly perpendicular to the branch. (Fig. 32, b.) It retains its embryonic form until several abdominal segments have been exposed, then the head bends down and

the thorax becomes strongly arched upward. (Fig. 32, c.) The young nymph continues to work outward by muscular contractions of the abdomen and by bending the body up and down and from side to side. The unexposed parts are wrapped in a delicate membrane which projects from the hole and clings to the body. The palpi and first two pairs of legs become free first and are then exercised in the air. (Fig. 32, d.) The body begins to straighten out again, pulling the antennæ with it. The head turns upward and a watery swelling, formed to fit the end of the egg, then becomes a conspicuous lump on the dorsal side. When the body is far enough out the free legs grasp the wood and assist in relieving the remainder of the body. The nymph holds the antennæ with the mouth parts and gives an upward pull. This is repeated until these appendages are released. (Fig. 32, e.) At about the same time the hind legs and tip of the abdomen become free. The whole process usually requires ten or twelve minutes, but a few of the insects never succeed in completely detaching themselves from the egg. The young cricket on emerging immediately crawls from the eggshell, usually upward on the branch. The watery lump on the top of the head continues to show for twenty minutes after the insect escapes from the egg, but within a short time after this period its disappears.

In 1909 and 1912 the nymphs began to make their appearance about June 14 and they continued to emerge until about the twentieth day of this month. In 1913 eggs that had been kept in the laboratory for five days commenced to hatch on June 6.

During the summer of 1913 individuals of this species were collected at intervals in the field in order to find out the normal time of appearance of each instar. The record is summarized as follows:

July 1. First specimen of nymph in second instar.
" 11. Third instar in maximum numbers; some still in second and a few in the fourth stage.
" 16. Fourth instar outnumbered third by five to one.
" 19. First appearance of fifth instar.
" 23. Fifth instar in minority.
" 25. Over half of insects in fifth instar, remainder in fourth stage.
" 29. Adults heard singing at night.
" 30. An adult which had just transformed collected in the field.
Aug. 5. Adults and nymphs in about equal numbers.

In the summer of 1912, which was colder than usual in New York, adults were not taken until August 15, and eight days later were about equal in numbers to the nymphs. On August 27 practically all of the crickets had matured.

SOME HABITS OF THE NYMPHS.

Feeding habits.— During the daytime the nymphs are very inactive and remain for the most part hidden in a curled leaf, with the antennæ stretched out in front and usually projecting beyond the edge of the leaf as if to detect the approach of any intruder. At night they are very active and crawl about to feed. They show signs of restlessness as evening advances and continue on the move throughout the night.

Molting.— When a nymph prepares to molt it first fastens its claws firmly in the bark or in the tissues of a leaf, extends the antennæ backward, and arches up the back. The skin splits along the dorsal median line of the head and thorax. The head is bent down and the thorax works out through the split. The fore and middle legs are pulled out and exercised, while the palpi and antennæ are still held in the skin. The hind legs are pulled upward and forward. The antennæ are partly pulled out by straightening the body, and then they are grasped by the mouth and worked out in the same manner as noted in the process of hatching. When the hind legs are free the nymph grasps the support and pulls out the hind part of the abdomen. Later the skin is eaten by the insect if in the meantime the discarded remnant has not been consumed by some other cricket.

MUSICAL STRUCTURES AND SONG OF ADULT.

The males begin to sing very soon after reaching the adult stage. In doing so they raise the front wings perpendicular to the body, with the inner edge of the right lapped over the left, and vibrate them rapidly in a transverse direction. The mechanism which produces the sound is found near the base of the wing, the broad, expanded distal part serving as a resonator to increase the volume of sound. A short but prominent transverse vein, about one-fourth way from the base, is modified beneath to form a minute filiform rasp. It is about 2 mm. long and bears forty or fifty short teeth inclined toward the opposite wing. Both wings have a rasp but the right always laps over the left, the inner edge of which is thickened at this point to serve as a scraper. From our observations the rasp of the left wing and the scraper of the right wing are little if ever used.

The song of *niveus* is one of the most conspicuous and musical of the insect sounds commonly noted in late summer and autumn. It can be heard from the time the insects commence to mature — early in August in this latitude — until they succumb to frosts of late October or early November. The song begins at the approach of darkness and continues until morning. Occasionally a few of the insects may be heard during the middle of day when the weather is very cloudy. The song consists of a monotonous series of clear, high-pitch trills rhythmically repeated for an indefinite length of time. The quality is that of a clear, mellow whistle and has best been described by the words, *treat — treat — treat.* The pitch varies somewhat with the temperature but on an ordinary summer evening it is about C, two octaves above middle C, or on a warm evening it may reach as high as D. The rapidity of the notes is directly dependent on the temperature. On a very warm night we counted 155 beats per minute, while on a cool night the number was only 64.

The song of different individuals may vary also in quality, intensity, pitch and rapidity of notes. There is, however, a tendency for the insects in a restricted site — as a raspberry plantation, clump of bushes or a single tree or a small clump of trees — to sing in unison in one synchronous movement.

MATING HABITS.

In addition to their musical qualities the males possess another alluring device to attract the females. This is a gland situated on the metanotum, which becomes exposed at the time the forewings are raised in the act of singing. Externally this structure appears as a rounded depression, with elevated margin, which contains numerous hollow, glandular hairs, and also two pairs of openings from much branched internal glands. When a female approaches the singing male, he turns his head away from her, when she usually mounts his back and partakes of the secretion of the gland. (Plate XXIX, fig. 1.) The male now stops singing and stands with his legs widely extended and wings raised to an angle of about 45 degrees. He appears to be in a state of great excitement, as shown by the twitching and swaying of the body and a peculiar jerky movement of the hind wings which lay folded along the abdomen. The antennæ are also waved about wildly and often thrown back so as to cross and rub against those of the female. The latter eagerly

bites and pulls at the thoracic gland, and at intervals stops to rest. During such a pause the male often resorts to singing as if to hold further the attention of the female. After she has fed on the gland for a half hour or more the male reaches back with his abdomen and simultaneously she bends her abdomen downward. He then protrudes a pair of small chitinous hooks, and with his cerci on each side of the ovipositor as guides, inserts these structures into a small notch at the end of the subgenital plate. This enables him to push the barbed capillary tube of a spermatophore into the opening. The abdomen is withdrawn and the spermatophore remains hanging. The latter is a white, hard, ovoid body about .85 mm. long with a central cavity filled with spermatic fluid, and opening out through a fine tube about 1.4 mm. long bent in the form of a hook. The sperms flow out through this tube into the seminal receptacle of the female. Following this act the female continues to feed at the dorsal gland for a quarter or half an hour. If she starts to crawl away the male renews his singing, apparently in an endeavor to dissuade her from departing from him. When she finally leaves she selects a secluded spot where seemingly she will not be disturbed. Later she arches up the back, bringing the tip of the abdomen forward beneath, and then reaches back with the head and removes the spermatophore. She straightens out again and proceeds to eat the capsule in a leisurely way. She then doubles up again and works at the ovipositor with her mouth, starting at the base and continuing out toward the tip, as if endeavoring to clean this organ.

OVIPOSITION.

For this operation the female selects a suitable spot on a tree or bush and prepares to oviposit by first chewing a small hole in the bark, choosing the upper side of a branch in preference to the lower side, and working with the head uppermost when on a sloping or vertical surface. Upon the completion of the cavity she then walks forward a little, arches her back so as to bring the ovipositor about perpendicular to the branch and begins moving it up and down until she strikes the hole. She then starts to drill by giving the ovipositor quick thrusts and at the same time slowly turning it around by twisting the abdomen thirty or forty degrees to each side. (Plate XXIX, fig. 2.) As the ovipositor is forced in it takes a more or less oblique course, according to the thickness of the bark, so that the

egg usually comes to lie nearly parallel to the surface. It generally takes from six to ten minutes to force the ovipositor to its base the first time, but in some cases it takes much longer, depending on the resistance of the bark. After the operation this organ is pulled nearly out and drilled in again several times, each effort taking about one and a half or two minutes. When the hole is sufficiently reamed out and the ovipositor drilled in for the last time the female forces out a drop of excrement and, by stretching out the tip of the abdomen, fastens it to the bark just below the hole. The egg is then forced down and the ovipositor is slowly withdrawn. The female pauses with only the tip remaining in the hole and deposits some mucilaginous substance. She then removes the ovipositor, moves a slight distance backward, seizes the drop of excrement in her mouth and places it over the opening. She then spends several minutes packing it in and smoothing it out so that the wound is neatly capped. (Fig. 31, c.) The whole process of depositing an egg, from starting to drill until the hole for the reception of the egg is sealed, may consume from twenty minutes to three-quarters of an hour. In our breeding cage experiments from one to thirteen eggs were deposited in a single night by one individual. Several of the insects laid a few eggs every night during the whole period of oviposition. On a few nights others did not oviposit at all. The largest number of eggs deposited by a single female was seventy-five, the smallest number twenty-four, and the average of eleven individuals was forty-nine.

The eggs are laid in the soft inner bark. A groove is often cut in the surface of the wood, but generally the hard tissues are not drilled into to any extent. In most plants a hard, woody capsule forms around the egg which completely encloses it with the exception of that portion in contact with the opening made by the ovipositor in the bark.

In trees having a rather soft, fleshy bark, such as apple and plum, *niveus* prefers to oviposit in fairly large branches from one to three inches in diameter. The eggs may be placed in almost any area in the bark, but a favorite location is in a lenticel where the initial drilling is more easily accomplished. (Plate XXXI, fig. 1.) In bushes and trees in which the large branches have a tough bark the eggs are commonly laid in the smaller branches in thick places in the bark on each side of the base of a small twig or bud. In raspberry canes, where the eggs are sometimes fairly common, oviposition usually occurs in the fleshy area at the side of the bud in the axils of the

leaves, and we have never found more than one egg on each side of a bud. (Fig. 31, b.) However, the egg never extends through the woody layer into the pith, as is the case with *nigricornis*. On elms, the eggs are mostly placed in the corky area of large or small branches, and they do not usually extend into the inner bark. Peach trees are seldom selected by *niveus* for oviposition. The reason for the apparent dislike of this species for this plant is not clear, since the eggs of *nigricornis* have been observed in considerable numbers in the current year's growth. In this connection it is of interest to note that in one series of breeding experiments *niveus* oviposited quite freely in the trunks and larger branches of a peach tree, but later the formation of gum was so great that the eggs were completely forced out of their positions. Oviposition largely occurs during the latter part of August and September.

SELECTION OF PLANTS FOR PURPOSES OF OVIPOSITION.

Oviposition experiments in breeding cages were conducted in the laboratory to determine what kind of plants the females preferred for the reception of their eggs. Each cage contained one or two males, with a single female. In the cages there were placed a short piece of apple limb one or two inches thick, a piece of raspberry cane with foliage, and a bunch of small, pithy weeds, mainly wild carrot (*Daucus carota*). In a number of cages there were also included short sections of branches, about one inch thick, of maple, willow, elm and poplar. Eggs were laid only in apple, raspberry, willow and elm. Of these, preference was shown for apple wood. One cricket laid its eggs entirely in raspberry and two others deposited a small part of their eggs in canes of this plant. One specimen laid a few eggs in willow and another placed four eggs in elm. Observations in the field have shown that this cricket deposits its eggs in a great variety of plants and that it prefers certain of them to others for this purpose. About Geneva its eggs are most abundant in apple, plum and cherry trees, and they are also somewhat common in walnut and raspberry. One small elm tree was observed to contain a large number of them and a few eggs have been found in peach, witch hazel, chestnut, butternut, wild crabapple, hawthorn, red oak, maple and lilac. Oviposition probably occurs in many other plants which possess bark of desirable thickness and not too resistant to the drilling operations of the insect.

DATES OF LAST APPEARANCE OF ADULTS.

In the autumn of 1912 specimens of this species were found on October 29, and males were heard singing on the night of October 30. These had lived through three light frosts, but none of the insects were found after heavy frosts on November 2, 3 and 4. In 1913 a good many females were found in apple trees on October 28 but no males were observed.

FEEDING HABITS.

This species subsists on a rather wide assortment of foods of both vegetable and animal origin, which are capable of being masticated by its comparatively weak mandibles. In rearing the crickets in cages we depended almost entirely on aphids and sugar solution, both of which were easily available and readily eaten by this and other species. The insect also ate holes in raspberry leaves and to a less extent in apple leaves. Under confinement *niveus* was often seen chewing at the cambium on the truncate ends of a severed branch and eating the green outer layer of wild carrot stalks. A disabled cricket or one unable to defend itself usually fell a victim to more vigorous individuals. For further knowledge of their natural feeding habits we dissected out the crops of a number of individuals and examined the contents with a microscope. The specimens of this species examined were in the fourth and fifth instars and all were taken from trees in a neglected apple orchard. In about half of them the crop contained a large proportion of materials of insect origin, while in the remainder the contents consisted largely of plant tissues. The latter was mostly leaf tissue, including cells with chlorophyll, leaf hairs and vascular tissue. Mycelia and spores of various fungi were present in smaller quantities. The contents derived from the eating of insects was usually so broken up that it was difficult to classify with any degree of certainty the different elements as to their origin. In quite a number of samples we found parts of what appeared to be the cast-skin of a tree cricket, which was probably its own, and in one specimen this was all the crop contained. Broken pieces of faceted eyes, which resembled those of an aphid, and antennæ of probably the same individual were found in several instances. In nearly all specimens remains of San Jose scales were detected, and in the contents of one crop the pygidia

of twenty-four of these insects were counted, and probably the remains of others were present in an unrecognizable condition.

The presence of San Jose scales in the crops led us to perform experiments on feeding the coccid to crickets. A small branch about one-half inch in diameter, thoroughly covered with scales, was placed in a cage with five specimens of *niveus* in the fourth instar. After two nights the exposed part of the stick, or about three inches in all, was entirely cleaned of the scales. In other experiments only one cricket was confined, this individual being allowed to feed on infested wood on which the number of the scales had first been approximated. In one instance a cricket over night disposed of about five hundred and forty scales, and during the next two nights approximately six hundred and twenty scales. On the fifth night it devoured nine hundred and eighty scales, while on the following night it ate seven hundred and sixty scales. The counts included both mature and immature specimens, and it should also be noted that the crickets ate both the protective covering or scale and the real insect beneath. These results indicate that when the crickets occur on infested trees this coccid, as well as others, probably forms a large part of their diet. Nevertheless, the San Jose scale is constantly spreading in orchards that are well stocked with tree crickets.

Another habit of this cricket which has attracted the attention of some entomologists is that of eating holes in fruits. We have found no examples of such injury in orchards in western New York, but in experiments where fruits were placed in cricket cages or the crickets were confined in cages built about fruits the insects ate round holes in them. The character of the injury is quite easily distinguished from the work of the more common orchard pests, for after making a small opening in the skin of the fruit the cricket works its way into the flesh and feeds with its head concealed within the hole. As a result the cavity increases in diameter below the external opening in the skin of the fruit. Peaches and plums were preferred to other fruits.

EFFECTS OF OVIPOSITION ON APPLE TREES.

The effect on the tree of oviposition by the female is to produce in the bark a small opening as if the tissues had been punctured by a coarse cambric needle. With the majority of egg punctures little damage results, since the wounds heal quickly, the only visible

injury being a discolored point or a tiny pit or depression surrounded by a narrow ring of dead bark. (Plate XXX, figs. 1, 2.) If oviposition were never attended with more serious consequences the work of *niveus* in this respect could hardly be considered of enough importance to warrant it being listed as a pest of the apple. Such, unfortunately, is not the case; for there is another form of injury which apparently arises from a contamination of the wounds made in the bark by the cricket by some infectious agent and appears as diseased areas. These, in their external appearances and effects, resemble superficially certain stages of the New York apple-tree canker (*Sphaeropsis malorum* Pk.) or the blight canker of apple trees (*Bacillus amylovorus* (Burr.) de Toni). The affected spots range generally from one-fourth of an inch to an inch in diameter, while the bark within these limits varies from purplish or reddish-brown to pale brown, depending apparently on the extent and age of the infection. (Plate XXXII, figs. 1, 2.) Usually most of the diseased areas are circular or somewhat oval in form, and occasionally one may observe a large irregular extension of the original infected area as if there had been a renewal of activities by the infectious agent. The bark within the area of infection is generally slightly depressed and may also be separated from the sound bark by a distinct line or narrow crack. (Plate XXXI, fig. 2, and Plate XXXII, fig. 3.) In more advanced stages cracks develop, separating the dead area from the surrounding tissues, and there is formed a core which adheres loosely to the wood (Plate XXXII, fig. 4), affording attractive situations for the woolly aphis. (Plate XXXII, fig. 6.) From the wounds made by the insect, located as a rule about the center of the diseased areas, one may observe in April or May more or less flowing of a gummy, reddish-colored liquid which on drying leaves a resinous product about the orifices of the wounds. (Plate XXXII, fig. 1.) Not infrequently there is an entire destruction of the bark which, on sloughing off, leaves the underlying wood core exposed in spots of varying dimensions. In some orchards such injuries occur to a serious extent. These conditions may be quite generally observed on trees along weedy roadsides or ravines or in apple orchards that are neglected or are indifferently managed. Orchards that are given careful attention are usually free from the trouble, although plantings — especially of young apple trees growing near neglected orchards or near raspberry plantations — have occasionally been observed which showed con-

siderable oviposition by *niveus* and here and there an egg puncture with the characteristic affected area surrounding it.

Of the insects in this State which produce scarification and disfigurement of bark and wood of apple trees the most prominent species, with the exception of the seventeen-year cicada (*Tibicen septendecim*), which is restricted to limited areas, are the buffalo tree-hopper and the snowy tree cricket, which are very common and widely distributed. Both insects are most injurious in plantings that lack care with respect to approved orchard practices. Both produce damage to trees as a result of their habits of oviposition, and not infrequently the effects of their work may be observed on the same tree. In the positions selected for the reception of the eggs and in the effects of egg-laying upon the health of the trees, the two insects show characteristic differences. The foregoing tree-hopper (*Ceresa bubalus*) deposits its eggs in the bark of the newer growth. In the case of young trees oviposition may be so extensive that portions of the tree are stunted and the tree becomes ill-shaped. The vitality of the older trees is generally not seriously affected, the principal damage being scarification and roughening of the bark if the deposition of eggs has been extensive. On the other hand *niveus* prefers for egg-laying soft, fleshy bark, preferably that of wood from one to three inches in diameter. By reason of this habit apple wood is subject to oviposition by this insect over an extended period of years, which results in considerable pitting, scarring and other disfigurations of the bark. (Plate XXX, fig. 1.) The extent to which apple wood is sought by this cricket for egg-laying purposes is best observed by removing the bark, which will reveal discolored areas in the cambium and wood (Plate XXX, fig. 2.) and by making cross sections of the wood as shown in Plate XXX, fig. 3. The chief damage by *niveus* on apples arises apparently from the establishment of a bark disease in its oviposition punctures, which causes the bark of the older wood to become scarred and roughened or kills the bark on the younger wood, with resultant weakening or death of small branches and twigs.

OCCURRENCE OF *Leptosphæria coniothyrium* ABOUT OVIPOSITION PUNCTURES.

Cultural and microscopical studies by Mr. W. O. Gloyer of the Department of Botany to identify the infectious agent which becomes

established in the oviposition wounds of the tree cricket have revealed the interesting fact that during 1913 the causal organism was in the majority of cases a species of fungus known as *Leptosphæria coniothyrium* (Fckl.) Sacc. (*Coniothyrium Fuckelii* Sacc.). According to Duggar [8] this is a fungus which, as a disease-producing organism, has been known only a few years. O'Gara [9] lists it as occurring on apple and rose at Washington, D. C., and on apples in a nursery near Clemson College, S. C. It is stated by this writer that most of the infections took place where the bark of the trees had been bruised or broken by tools or harness in cultivating. In New York this fungus had, up to the time of this investigation on tree crickets, attracted no attention either as an apple or as a rose pest; but since 1899 it has been regarded in this State as the cause of a widespread and serious disease of raspberries, which is popularly known as raspberry cane blight. It is essentially a wilt disease and the principal damage results to the fruiting canes. The whole cane may be involved or only a portion of it. Stewart and Eustace [10] believe that infection occurs in wounds of various kinds and that a break in the epidermis usually precedes the attack. They also state that cane-blight often starts in wounds made by the " heading back " of new canes, by the removal of branches, by the rubbing of canes against each other or against supporting wires, particularly in crotches where the branches are more or less split apart and in wounds made by the snowy tree cricket *Œcanthus niveus* (*nigricornis*) during oviposition. That infection does actually occur in tree-cricket wounds is shown by the large number of instances in which the cane is covered with *Coniothyrium* pycnidia in the vicinity of the wounds, usually just below them."

The occurrence of *Coniothyrium* about the oviposition punctures of *niveus* in apple bark have suggested that this cricket may act as a carrier of the disease. In studying the feeding and egg-laying habits of this insect it appears that infection of apple bark might take place (1) as a result of wounds produced by the gnawing of the bark by the female as the initial step in the act of oviposition; (2) by means of the ovipositor, the adhesive substance discharged at the time of deposition serving to collect and to hold the spores which

[8] B. M. Duggar, Fungous Diseases of Plants, p. 354. 1909.

[9] P. J. O'Gara, *Phytopathology*, 1: 100. 1911.

[10] F. C. Stewart and H. J. Eustace. N. Y. Agr. Exp. Sta. Bul. 226 (1902); and F. C. Stewart, N. Y. Agr. Exp. Sta. Bul. 328, p. 387 (1910).

may be left in the holes during the drilling process; and (3) by the introduction of spores in the oviposition punctures on account of the remarkable habit of the insect, which employs its excreta to close the openings in the bark after the deposition of the egg. Experimental proof of such carriage of the disease is, however, lacking, but studies to this end are being conducted by this Station.

SUSCEPTIBILITY OF TREE CRICKETS TO SPRAYING AND OTHER ORCHARD PRACTICES.

The occurrence of comparatively small numbers of tree crickets in well-cared-for orchards, except as they adjoin raspberry patches and weedy areas, indicate that the conditions that exist in such plantings are not congenial to these insects. The behavior of the tree crickets in this regard is strongly suggestive of the habits of well-known apple-maggot (*Rhagoletis pomonella*) in apple plantings in this State. Both insects thrive best in neglected orchards and are for the most part of little importance in plantings that are carefully managed. It appears that such approved practices as pruning, cultivation and spraying afford protection to the trees from these pests. As with the apple maggot, a satisfactory explanation as to how these operations affect tree crickets is lacking. As yet we have to fall back on suppositions. It does not appear that pruning as ordinarily carried out in commercial orchards would have any appreciable influence on the numbers of the crickets. Clean culture would likely prove unfavorable to them. Following storms and high winds they may sometimes be found on weeds and other undergrowth, and the absence of such plants in cultivated orchards might prove detrimental to the insects by rendering them more exposed to the attacks of birds and other foes. Moreover in view of the phytophagous habits of these creatures a hypothesis which seems quite probable is that as a result of applying arsenate of lead to apples, as is now so extensively practised in commercial plantings, the crickets actually feed on sprayed foliage and succumb to this poison.

In the absence of data bearing on this latter point it seemed desirable to determine the effects of applications of arsenicals at usual strengths to foliage upon these insects, and to this end two tests were conducted by confining different lots of crickets, of five to six individuals, to sprayed and unsprayed foliage of apple trees. In the

use of the poison the arsenate of lead was allowed to dry before the insects were introduced in their respective cages. As an additional check on these tests a liberal supply of plant lice was supplied to several of the lots after the spray had dried on the foliage. Some of the details of these tests and results of the different treatments are indicated in the accompanying tables.

Table I.—Effects of Arsenate of Lead on Tree Crickets.

On *Œcanthus angustipennis.*

No. of Lot	Treatment.	Effect after ten days.
1	Lead arsenate*	All crickets dead.
2	Lead arsenate	" " "
3	Lead arsenate and a supply of plant lice	" " "
4	Lead arsenate and a supply of plant lice	" " "
5	Check	All crickets alive.
6	Check	" " "

On *Œcanthus niveus.*

No. of Lot	Treatment.	Effect after ten days.
1	Lead arsenate†	All dead.
2	Lead arsenate and a supply of plant lice	" "
3	Check	All alive.

*Poison applied July 16. †Poison applied July 25.

The above tests are not as conclusive as we should desire because of the small numbers of crickets in the different lots and the little freedom given them for foraging activities. However, the results point out the fact that these creatures are, under certain circumstances, leaf-eaters and suggest that they, in common with other species of insects with leaf-eating habits, run risks from arsenical poisoning in well-sprayed orchards.

PREVENTIVE AND REMEDIAL MEASURES.

The facts brought forth in this bulletin indicate that the snowy tree cricket is most abundant in neglected orchards and that there is little to fear from this insect in plantings that receive careful attention. Cultivation to destroy foreign vegetation, as weeds and brush, about and in the orchard and to keep the ground about the trees clean is especially recommended. Such treatment seems not only to afford protection from the tree crickets, but in the case of orchards which lack vigor the trees will be stimulated to outgrow the various disorders to the bark that have attended oviposition by these insects. While the susceptibility of this species to arsenicals has not been conclusively demonstrated, it is believed that the

numbers of crickets are materially reduced by summer applications of these poisons. Both of these measures — clean culture and spraying with arsenicals — are fortunately standard orchard operations which are invariably practised by the most successful fruit-growers.

THE NARROW-WINGED TREE CRICKET.

Œcanthus angustipennis Fitch.

HISTORICAL NOTES.

This species was first described by Fitch [1] as a variety of *niveus* from a single male specimen. The description is very brief and the only distinguishing character mentioned is the narrow wing covers. Beutenmüller [2] says that this characterization "applies equally as well to *quadripunctatus* as to the insect determined by recent writers as *angustipennis*. Whether the latter has been correctly determined or not can never be definitely ascertained, as Fitch's type of the species, as well as all his other species of *Œcanthus*, have been destroyed. I would propose that the name *angustipennis* nevertheless be retained for the species so well known to us by this name." This species is not generally as familiar to economic workers as *niveus*, although it has somewhat similar habits. References to the insect are largely found in systematic writings, and as regards its life history and habits very little has heretofore been published.

DISTRIBUTION.

Our knowledge of the extent of distribution of this species in New York is very limited. It is common in the lake region of the western part of the State and on Long Island, and probably the insect ranges over about the same territory as *niveus*. It has been recorded in literature from other states as follows: Massachusetts (Faxon), Connecticut (Walden), Georgia, Florida, Texas (Allard), Illinois (Forbes), Kentucky (Garman), Kansas (Tucker), Minnesota (Lugger). From specimens examined we can record it from the following states: New Jersey, North Carolina, Florida (Amer. Mus.), Virginia (Schoene), Ohio (Kostir). Of the states mentioned, Minnesota represents the most northern limits of distribution, while Texas appears as the most western area of its occurrence.

[1] Fitch, Asa. 3rd Rpt. on Insects of N. Y. Trans. N. Y. Agr. Soc., 1856, 413. 1857.

[2] Beutenmüller, Wm. *Bul. Amer. Mus. Nat. His.* 6: 251. 1894.

DESCRIPTION OF LIFE STAGES.

Egg.— (Fig. 33, b) The eggs are white and average a trifle smaller than those of *niveus*. The cap is narrower than in the latter species and varies greatly in length. Short specimens (Fig. 33, d) measure about .4 mm. in length and breadth, while the long ones (Fig. 33, c) reach .7 mm. in length, have a broad base and taper down to a rather narrow tip. The projections of the cap are short and thick, measuring about .011 mm. in breadth by .014 in length. (Fig. 33, e.) The end of the cap is broadly rounded and the base slightly constricted.

The average measurements of twenty specimens of eggs are as follows: length, 2.77 mm.; greatest width, .51 mm.; length of cap, .48 mm.; width of cap, .42 mm.

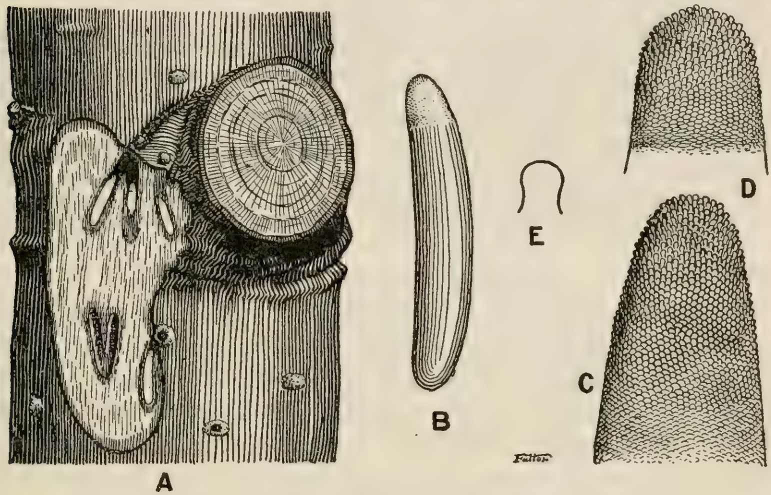

FIG. 33.— NARROW-WINGED TREE CRICKET.
a, Egg punctures in apple wood (× 3); b, egg (× 15); c, d, long and short egg caps (× 50); e, spicule of egg cap (× 500).

Nymph.— First instar: Color white. Markings of head and thorax as in following stage. Antennæ entirely white; occasionally with a dark spot on the inner edge of the first segment. Hind femora with a few black spots near distal end; hind tibiæ with a conspicuous black space at distal end covering about one-sixth of entire length. Length 3 to 3.3 mm. Antennæ 8 mm.

Second instar: Color greenish white. Head with a short black line above and back of each eye, and with black specks at the base of minute bristles between eyes and antennæ. Thorax with a pair of dark lines near the median line. First segment of antenna with a black spot on the inner edge. Outer half of antenna very faintly annulated. Hind femur with only four or five black spots on the outer side near the distal end. Length 4.5 to 5 mm.

Third instar: Dorsal area of abdomen pale green with a small median white spot on hind margin and a pair of white spots near front margin. Sides pure white. Basal antennal segment with the black spot on inner edge; and most specimens have a more or less distinct short line on the front side near the inner edge. Second segment with a small black spot on the front and inner side. Length 6 to 7 mm.

Fourth instar: Pale green. Head slightly yellowish above. Two median longitudinal lines of pronotum faint. Median area of abdominal segments pale yellowish green; the three white spots are relatively small. Upper part of side of each segment with a large elongate white spot reaching from front to hind margin, constricted or divided in the middle and surrounded by a ground color of pale yellow. Sides below are pure white. Antenna with a rather prominent white lump on the front and inner side and bounded on the outer side by a curved black mark. Second segment with an elongate spot. Length, 8 to 10 mm.

Fifth instar: Top of head between eyes yellow or pale orange. Median area of pronotum greenish; with two faint dark median lines. Abdominal markings as in the fourth instar. White prominence on the first antennal segment, with a black J-shaped mark; and the second segment with an elongate spot. Hind femora with a few black spots near the extremity. Length 11 to 12 mm.

Adult.— Very slender. Pronotum a little longer than greatest breadth. Color very pale green. Light specimens have the top of the head between the eyes and antennæ yellow, and have a faint gray longitudinal streak on the pronotum. Darker specimens have the top of head orange yellow or even burnt sienna and the streak on the pronotum is strong brownish gray. Wings transparent, with greenish tinge and greenish veins. Fore wings of male comparatively narrow. Antennæ faintly annulated with gray on the distal part. The first segment is yellowish with the exception of a white prominence on the front and inner side, which bears a black J-shaped mark, with the crook turned inward. (Fig. 30, b.) Length to end of abdomen 14–15 mm. Forewing of male 10–12 mm. x 4–5 mm. Forewing of female 12 mm.

DURATION OF NYMPHAL STAGE.

Angustipennis was first discovered in association with *niveus* on apples during the summer of 1913 when the nymphs were mostly in the third instar, and for this reason we have made very few observations on its early life history. This species passed through the various nymphal stages about a week or more later than *niveus*, which may have been due to a slower development or to a later time of hatching. On July 16 the nymphs were generally in the third stage and on July 25 they were practically all in the fourth instar, while on these two dates *niveus* was mostly in the fourth and fifth instars respectively. The adults also matured, on the average, later than the latter species.

During the latter part of October the adults become very inactive and may often be observed clinging to the trunks and larger branches of the trees. At this time the males are apt to be very few in number and apparently they die off earlier than the females. In the fall of 1912 living females of this species were found as late as October 29, and on November 3 dead ones were found on the trunk of an apple tree. In 1913 a large number of females in fairly active condition were taken in an apple orchard on October 28, but no males could be found on this date.

SONG AND MATING HABITS.

The song is intermittent but readily distinguished from *niveus* by its longer notes and rests and by its non-rhythmical character. The pitch is from C♯ to D♯, two octaves above middle C, depending on temperature and somewhat on individual variation. The sound is not so loud as that made by *niveus* and is of a more mournful quality. Each trill continues from one to five seconds, but it lasts most commonly for about two seconds. The periods of rest vary more and may be from one to eight seconds or longer. On one occasion a specimen alone in a cage was observed to trill continuously for a minute or more. Out of doors the song would be unnoticed by anyone not endeavoring to detect it. On trees where *angustipennis* occurs in equal abundance with *niveus* the song is nearly drowned out by the synchronous beat of the latter species and only by listening intently can it be detected. So far as we have observed it sings only at night. The method of producing the sound and the structures that make it possible are essentially the same as described under *niveus*. On account of the narrow forewings, however, the rasp is not so long and the resonating surface is not so great, which may, at least in part, account for the feeble production of sound by this species.

The mating habits are essentially the same as those of the preceding species.

LOCAL DISTRIBUTION.

This cricket occurs quite often on the same trees with *niveus*, but while individuals of this species are very abundant in apple orchards they are, however, not so much confined to these trees as are those of the latter. On Long Island we found this insect quite common on oak trees, especially the scrub and burr oaks, and in a swamp near Geneva there were considerable numbers on alder bushes. We have never taken *angustipennis* on raspberries, grape, or weeds of any kind.

FEEDING HABITS.

An examination of the crop contents of a number of specimens collected on apple trees shows that this species has food habits very similar to *niveus*. Leaf tissue, fungus mycelia and spores, aphids, San Jose scales and moulted skins comprise the bulk of its food. In two individuals we found a number of lepidopterous wing scales while in another specimen a leg and the wings of some small hymenop-

terous insect were detected. The discovery of twenty-eight recognizable pygidia in the crop of one individual shows that this species, like *niveus*, may feed extensively on certain kinds of scale insects.

OVIPOSITION.

The female usually selects a small branch of about a half or third of an inch in diameter in which to place her eggs. She drills into the thick, wrinkled places in the bark where the small twigs branch. The details of the various operations in connection with egg-laying are, with a few exceptions, as described under *niveus*. We have not observed this species using a drop of excrement to seal the hole in the bark after the deposition of the egg. For this purpose she bites off particles of bark near the puncture and pushes them into the hole, making a little round pellet. It sometimes happens that the female does not completely remove the ovipositor after laying the first egg but starts to drill another hole in a slightly different direction and deposits a second egg without appreciably changing her original position. (Fig. 33, a.) From examinations of a large number of egg punctures in orchards about Geneva we have found only a few paired eggs, and our caged crickets from this section laid very few eggs in this manner. Apple branches from West Virginia and Kentucky contained large numbers of these double punctures (Plate XXXIII) as well as single ones, and live, caged specimens of this species sent to us from Kentucky deposited fully half their eggs in pairs. This slight difference in habit between individuals of this species living in New York and those collected in West Virginia and Kentucky seems to be merely a physiological variation and is apparently not accompanied by any deviation of importance either in structure or coloration of the nymphs or adults.

ECONOMIC IMPORTANCE.

This insect has habits quite similar to the foregoing species and ranks with it in economic importance. In his studies of the two species in Kentucky, Garman[1] states that *angustipennis* was the more common in cutting fruit of peaches, plums and grapes. (Plate XXXVI, fig. 2.) A serious result of the rupturing of the skins of these different fruits was the development in the wounds of such

[1] H. Garman. Ky. Agr. Exp. Sta. Bul. 116.

destructive diseases as brown rot and black rot. In New York we have observed no damage by this species as a fruit pest. As has been suspected of *niveus*, there seems to be good evidence that this insect is in some way connected with the transmission of a bark disease of apples. Hopkins[2] has described the occurrence of diseased areas or cankers which he detected about the egg punctures of a tree cricket in apple orchards in West Virginia. He states that this peculiar injury to apple trees appears to be "quite common in all old orchards and is quite a serious trouble in some localities." The character of the injury is clearly shown in Plate XXXIII.

"A quite small and nearly round puncture is made through the outer bark, and from one to two long cavities are formed in the inner bark and sometimes grooving the outer surface of the wood. The wound thus made sometimes heals without doing harm but it often causes a blighted condition of the bark as shown in [Plate XXXIII, fig. 1,] and if the entire branch does not die, and it often does not, the woolly aphis attacks the edges of the wound and prevents it from healing. Thus an ugly scar or deformed place is the result as in [Plate XXXIII, figs. 2, 3]. Many branches so injured ultimately break off or die, so that the injury to a tree may be such as to cause it to rapidly deteriorate and soon become worthless as a fruit producer.

"It appears that the insect does not oviposit in rapidly growing branches on young trees, but selects those which are making slow growth. Thus when the wound is attended with blight and is subsequently attacked by the woolly aphis the wound seldom heals, the exposed wood commences to decay, and the branch dies, breaks off or becomes unproductive."

The identity of the species was not discovered by Hopkins, but from his description of the paired egg punctures there can be little doubt that at least part of the injury as described was due to oviposition by *angustipennis*. We have examined a number of small branches from West Virginia which were well covered with cankers. The branches were about one-half or three-quarters of an inch in diameter, and some of the cankers showed an area of bare wood in which the groove made by the ovipositor of the cricket could be plainly seen. A good many of the egg punctures were paired, and *angustipennis* is the only species we know which lays its eggs in this manner in the bark, although it also deposits them singly.

[2] A. D. Hopkins. W. Va. Exp. Sta. Bul. 50. 1898.

PREVENTIVE AND REMEDIAL MEASURES.

The similarity in the behavior of *angustipennis* to *niveus* in apple orchards suggests that this insect is susceptible to the same measures as outlined in detail for the latter species.

THE STRIPED TREE CRICKET.

Œcanthus nigricornis Walker.

This is apparently the insect described by Fitch[1] in 1856 as *Œ. fasciatus* De Geer, but according to Beutenmüller he "erroneously mistook his insect for De Geer's[2] *Gryllus fasciatus* which is a *Nemobius*." A description at a later date by Walker[3] under the appellation of *Œ. nigricornis* fits the striped tree cricket very well, and for this reason Beutenmüller[4] in 1894 recommended that this name be accepted since Fitch did not really denominate the insect. As stated previously Walsh and Riley considered this tree cricket as a dark variety of *niveus*. Others have also held that *nigricornis* and *quadripunctatus* are varieties of the same species, but in our studies of these two insects we have found constant differences in their habits as well as body characters, which have led us to regard them as quite distinct insects.

DISTRIBUTION.

This tree cricket is very common and is widely distributed over New York and throughout the United States. From literature it is recorded as follows: Massachusetts (Faxon), Connecticut (Walden), New Hampshire (Henshaw), New Jersey (Davis), Ontario (Walker), Tennessee (Morgan), Mississippi (Ashmead), Michigan (Allis), Illinois (Forbes), Minnesota (Lugger), Nebraska (Bruner), Oklahoma and Arizona (Caudell), Texas and Kansas (Tucker). From specimens examined we can record it from the following states: New Jersey and Connecticut (Amer. Mus.), North Carolina (C. L. Metcalf), Ohio (Kostir).

[1] Fitch, Asa. 3rd Rpt. in Trans. N. Y. State Agr. Soc. for 1856, pp. 414–415. 1857.
[2] De Geer, Charles. Memoir pour servir a l'historie des insectes, Tome III, 522–23, pl. 43, fig. 6. 1773.
[3] Walker, Francis. Cat. of Dermaptera Saltatoria of the Brit. Mus., I. 1869.
[4] Beutenmüller, Wm. *Bul. Amer. Mus. Nat. His.* 4: 250. 1894.

DESCRIPTION OF LIFE STAGES.

Egg.— The eggs (Fig. 34, c) are of a light or medium yellow color, and brightest when first laid. The cap is smaller than that of *niveus*, broader than long and hemispherical, the sides being parallel only at the extreme base. (Fig. 34, e.) The color of the cap is dull white but is sometimes stained reddish when in certain plants. The projections are short, cylindrical, and rounded at the tips. (Fig. 34, d.) Those near the end of the cap are .012 mm. long by .008 mm. in diameter. The eggs are more uniform in size than those of *niveus* and are generally narrower. Average measurements of thirty-six specimens are as follows: Length 2.9 mm.; greatest width .57 mm.; length of cap .33 mm.; width of cap .44 mm.

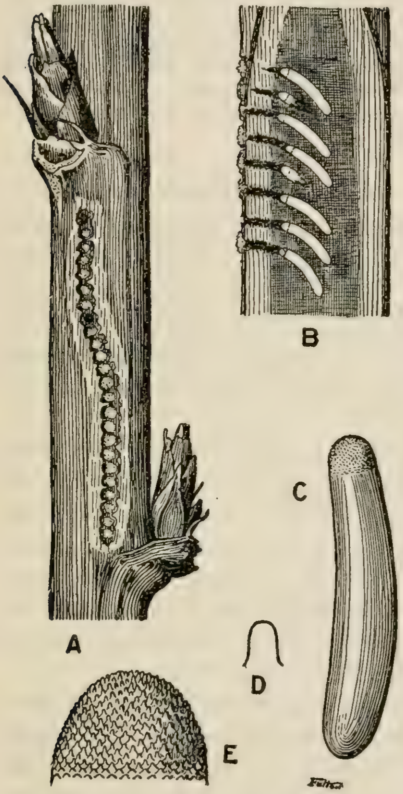

FIG. 34.— STRIPED TREE CRICKET.
a, Egg punctures in raspberry ($\times 1\frac{1}{2}$); b, longitudinal section of the same ($\times$ 3); c, egg ($\times$ 15); d, spicule of egg cap ($\times$ 500); e, egg cap ($\times$50).

Nymph.— First instar: Color, pale slightly greenish yellow. A slight infuscation extends along the dorsal side from the antennæ back, and is divided along entire length by a narrow pale median line. Just back of the antennæ the median line meets a pale transverse curved line which arches posteriorly. On the abdomen the shaded area is bounded on each side by a pale line which is in turn bordered by a faint dark line. The antennæ are gray all over but darkest toward the extremity. Length 3 mm. Antennæ 6 to 6.8 mm.

Second instar: Pale greenish yellow with scattered whitish flakes. Pale dorsal median line present, dorsal infuscation very faint. The two basal antennal segments are pale in color and the first segment has a dark longitudinal streak on the inner edge of the front side. Length 4 to 5 mm.

Third instar: Yellowish green, mottled with small whitish spots and with a pale median line. Legs speckled with fine dark spots at bases of hairs. Markings of basal antennal segments of the same pattern as in adult, but faint. Length 6 to 7 mm.

Fourth instar: Antennal markings distinct. Slight infuscation on head and pronotum, bordering the median pale line. Length 8.5 to 10 mm.

Fifth instar: Dorsal part of head slightly brownish. Hairs on body mostly dark. Legs appear rather dark, due to numerous dark hairs and spots. The spots on the basal antennal segments are large and conspicuous but not confluent. Ventral side of abdomen slightly infuscated and covered with small brownish spots. Length 11 to 12.5 mm.

Adult.— The amount of color in this species varies considerably and newly moulted specimens are lighter than old ones. The light specimens are greenish yellow. Head with blackish or sepia shading on median area, sides and front below the antennæ.

Pronotum with similar shading on sides and median area. Wings clear with greenish yellow veins and tinge of green between veins on inner edge. Femora dull green; tibiae and tarsi black. Antennæ black; first and second segments greenish yellow. The first segment has a brownish shading covering the inner and upper part of the front side, and including a heavy black line along the inner edge and a black spot near the distal end, which may be confluent with the black line. Second segment with two elongate black spots. (Fig. 30, c.) Venter of abdomen solid black; the remainder greenish yellow. Dark specimens late in the season have the head, pronotum, legs and antennæ nearly entirely black. Both pairs of spots on the two basal antennal segments are confluent (Fig. 30, d) and in some specimens each of these segments are almost entirely black. Length of body, 15 mm. Forewing of male, 10–11 mm. by 4–5 mm. Forewing of female 11–12 mm.

HATCHING OF EGGS AND DURATION OF NYMPHAL INSTARS.

In 1909 the young of this species began to emerge just before June 17. In 1913, eggs from the southern part of the Hudson Valley hatched June 7; some eggs from Connecticut began to hatch on June 10, while of a shipment received from New Brunswick, N. J., on June 10 a little more than one-half of the eggs had hatched. During this same year eggs of this species collected about Geneva hatched in largest numbers on June 16 and 17.

A study of the eggs in their natural positions in the wood shows that generally they slant downward from the hole, and since the dorsal side of the embryo is always next to the concave curvature of the egg the young cricket on hatching first appears upside down. In some observations of young insects in captivity it was observed that they displayed cannibalistic tendencies, and the cricket that emerged first would not infrequently attack those that were in process of emerging from the eggs and devour them.

During the summer of 1913 the first specimen in the second instar was found on July 2. On July 12 five specimens were taken in the third instar, and on July 17 there were about twice as many of the crickets in the fourth instar as in the third stage. On July 25 a few of the insects were in the fifth instar, but the majority of them were in the fourth stage. On August 5 most of the crickets were in the fifth instar, but no adults had so far been observed. However, adults were found several days later.

In 1912 no adults could be found on August 13 but a few of them were detected on August 20. On August 23 adults and nymphs of the fifth instar were present in about equal numbers, and by the 27th nearly all the nymphs had matured. The records for 1912 are probably several days later than normal as the summer was unusually cool.

SONG.

The song is a shrill continuous whistle, whirr-r-r-r-r, which may continue for a period of several minutes. In quality it most resembles the sound of a small tin whistle. The pitch on an average summer evening is F♯, two octaves above middle C. On a very cool night the pitch drops a little and the sound becomes much fainter and is not nearly so easily detected as the clear notes of *niveus*.

The song of *nigricornis* can easily be distinguished from the two preceding species, *niveus* and *angustipennis*, by its continuous note; the others having an intermittent sound. However, another common species not included in this article, *quadripunctatus*, has a song so closely resembling that of *nigricornis* that the two sounds are difficult to distinguish, even by one well acquainted with them. On the average the song of the former is fainter, less shrill and of a more rasping quality. *Nigricornis* can usually be heard in the vicinity of berry patches and tall weeds during the daytime as well as at night. In the morning only an occasional individual engages itself in singing, but in the afternoon more of the insects participate, and by evening the chorus appears in its greatest numbers and continues in full force throughout the night.

MATING HABITS.

The mating of *nigricornis* may begin before dark and pairs of the insects can generally be observed late in the afternoon clinging to the stalk of some tall weed or hiding on the undersides of the leaves. The female feeds eagerly at the thoracic gland of the male and, as is the case with the preceding species, he attaches the spermatophore at the base of her ovipositor. Judging from Hancock's[1] account and from our own observations the performance of this function is carried out in all the details as has been described for the snowy tree cricket.

OVIPOSITION HABITS.

In preparing for oviposition the female usually selects a position on the bark which is well above ground, the height depending largely on the diameter of the stalk and the kind of plant. In grape vines and certain weeds, stems not more than five millimeters in diameter

[1] J. L. Hancock. *Amer. Nat.* Jan., 1905, and Nature Sketches, pp. 383–384. 1911.

are often chosen, but in raspberry canes and elder the common thickness of the wood in which the eggs are laid is not much under a centimeter. If the stalk is vertical the female apparently manifests no preference as to choice of position, but if the plant slants a little she almost invariably chooses the uppermost side. In places where strong prevailing winds have caused all the weeds in a locality to lean in the same direction it will usually be found that nearly all the eggs are placed on the exposed side of the stalks of the plants. Before drilling, the female chews a small hole in the outer bark. She then arches up her body, brings the ovipositor forward perpendicular to the stalk, places the tip of it in the hole which she has previously made, and begins to drill. It takes about five minutes to push in the ovipositor for the first time. After this operation is done she reams out the hole by pulling the ovipositor nearly out and drilling it in a few more times. The egg is then forced down and she slowly pulls out the ovipositor, pausing with the tip of this organ in the hole to exude a small quantity of mucilaginous substance. In the case of one individual an egg protruded from the underside of the ovipositor when it was withdrawn. The female extracted the egg from its position with her mouth and ate it. Again she chewed the bark about the margin of the hole and then resumed drilling. After about eight minutes she withdrew the ovipositor and as before another egg was caught in this organ, which she disposed of in the same manner as the first one. In both instances a large quantity of mucilaginous liquid was discharged at the time of the extraction of the eggs which she removed from the ovipositor by her mouth before renewing operations. After an egg is deposited the female as a finishing touch to the process of oviposition bites out small pieces of bark just above the egg puncture and places them in the hole, carefully kneading them with her mouth parts to make a neat cap over the opening. The spot where the bark is removed serves as the next position for the drilling operations preparatory to the deposition of another egg. This process is continued until a number of eggs, forming a row, are laid. (Fig. 34, a, and Plate XXXIV.) The total number of eggs deposited varies greatly with individual crickets. In 1910 the records of six pairs confined in breeding cages were respectively as follows: (1) 165 eggs, (2) 64, (3) 26, (4) 78, (5) 52, (6) 31. During 1913 three pairs deposited respectively 22, 51 and 60 eggs. The eggs were deposited in rows

of from seven to twenty-one punctures. Occasionally the number of eggs in a series was increased over night or over a succession of nights at varying intervals by ovipositions by the same female. Observations in a patch of raspberries showed that the number of eggs in a row ranged from two to eighty-seven. The average number in nineteen rows taken at random was about thirty-two eggs. The longest row found in a willow twig had eighty-seven egg punctures, which strangely enough are also the highest figures for oviposition in raspberries.

The eggs are placed in rather compact rows with from seven to ten punctures to each centimeter. They lie in a slanting direction across the central pith cavity, the angle being about 40 to 50 degrees, depending somewhat on the diameter of the stalk. (Fig. 34, b.) The capped end of the egg lies within one or two millimeters from the opening of the hole and the egg usually slants downward from the opening instead of upward, since the female normally stands head up while ovipositing. When the rows are compact the eggs are generally directed alternately to the right and left so that they do not interfere with each other. In plants with a large pith cavity the eggs lie wholly within that part, but in those with a small central pith the cap end is partly imbedded in the woody tissues. The oviposition period for this cricket commences during the latter part of August and may extend through the month of September.

PLANTS SELECTED FOR OVIPOSITION.

This species prefers for the reception of its eggs plants which have a central pith surounded by a woody outer layer, and there are a great many plants of this character which are selected by the insect for this purpose. Eggs are deposited most abundantly in raspberry, blackberry, *Erigeron canadensis* and the larger species of *Solidago.* They are also common locally in elder, grape, sumac and willow. A few eggs may occasionally be found in the twigs of peach[2] (Plate XXXVI, fig. 1), apple,[3] elm, maple and hickory. Mr. Goodwin of the Ohio Station writes that considerable oviposition by this species occurs in peach orchards and vineyards in northern Ohio, especially on trees and vines which adjoin uncultivated fields. Similar conditions with respect to vineyards have been noted in the grape-growing region in Chautauqua county, New York. Mr. W. T.

[2] From material collected by J. L. King at Gypsum, Ohio.
[3] From material collected by B. G. Pratt, New York City.

Davis of Staten Island reports that he has also found eggs of this insect in wild cherry, white ash and *Baptisia tinctoria.* In going over the literature of this species we have found numerous descriptions of the work of this insect in various plants besides those given above, but always under the name of *niveus.* When the eggs are described as deposited in long rows there is little doubt as to their identity; for the only other widely distributed species with this habit is *Œ. quadripunctatus*, which deposits eggs only in smaller and more delicate plants. On this assumption additional host plants as recorded in literature are currant, Helianthus, artichoke, Ambrosia, plum, cottonwood, box elder, cherry, dogwood, black locust, honey locust, sycamore and catalpa.

LOCAL DISTRIBUTION OF THE INSECT.

The foregoing list of plants furnishes a very good key to the habitat of this species. It will be noticed that most of the plants named are those which grow best in low, moist places and some are characteristic of waste places. While the list contains quite a number of trees, it has been our experience that oviposition in these is only of rare or local occurrence or as a result of small seedling trees growing among other plants. The two types of localities where these tree crickets occur in greatest abundance are low lands with a dense growth of tall herbaceous plants, such as *Solidago, Erigeron, Helianthus*, etc., and on land of any kind that has grown up to bushes, briars and wild grape vines. The insects are less common in cultivated berry patches, nurseries and orchards, but even in these situations and especially in raspberry plantings they are sometimes numerous enough to be destructive.

FEEDING HABITS.

We have observed this species in the field feeding on the petals and anthers of flowers and on raspberry leaves and fruit. (Plate XXXVII.) Only in the cages have we detected it feeding on plant lice or other insects. An examination of the crops of a number of specimens mostly in the fourth instar collected in a raspberry planting, indicates that they feed more extensively on plant than on animal matter. In a few instances there were distinct insect remains, but these constituted a small part of the entire contents of the crop, which was mostly filled with leaf tissue, some fungus mycelium and spores.

ECONOMIC IMPORTANCE.

Of the known species of tree crickets, this insect has received most consideration in economic treatises. It has derived its reputation as a destructive pest from its work on raspberry and blackberry, especially the former plant. The injuries it causes arise from the long series of punctures which it produces in the canes during the process of egg-laying. As a result of the rupturing of woody tissues, the cane splits at the point of injury and becomes so weakened that it eventually breaks down from the weight of the upper growth or from twisting by the wind. (Plates XXXIV and XXXV.)

This species may commonly be observed in plantings of raspberries, and usually more or less numbers of the canes will, during the fall, show the characteristic wounds by this pest. Important damage occurs when there is extensive oviposition, which may result in the destruction of as high as seventy-five per ct. of the bearing wood. Such extreme injury is, however, rare, and in most raspberry plantations the loss caused by the insects is limited to the death of occasional canes.

As previously indicated, Stewart and Eustace state that the oviposition punctures by this insect may afford a lodging place for the spores of *Leptosphæria coniothyrium* (Fckl.) Sacc. (*Coniothyrium Fuckelii*), which is the organism responsible for the disease of raspberries, commonly known as the raspberry cane blight. They further suggest that the well-known tendency of cricket-injured canes to break at the point of attack is probably due, in part, to brittleness induced by the *Coniothyrium* and that the injury done by the cricket may be much aggravated by the cane blight fungus.

PREVENTIVE AND REMEDIAL MEASURES.

For the protection of raspberries and blackberries chief reliance should be placed on the prevention of attacks rather than in the destruction of the insects after they have made their appearance on the vines. Important injury may generally be averted by clean culture and the destruction of weeds in and about plantings of these fruits. Canes showing extensive oviposition and that are splitting should be removed in the course of winter and spring pruning and burned to destroy eggs contained in them. The foregoing measures ordinarily afford the needed protection; but should they fail a permanent reduction in the numbers of the tree crickets could doubtless

be effected by systematic spraying during the months of July and August with arsenate of lead at the usual strengths for foliage treatment.

ACKNOWLEDGMENTS.

For notes on habits and distribution and for assistance in collecting material on Long Island, we are indebted to Mr. W. T. Davis, Staten Island. The identifications of parasites were made by Mr. A. A. Girault, formerly of the University of Illinois and Mr. J. C. Crawford of the U. S. Bureau of Entomology. Mrs. L. L. Van Slyke kindly furnished notes on the musical qualities of a number of tree crickets, and Messrs. W. E. Rumsey and L. M. Peairs of the West Virginia Experiment Station and Mr. W. J. Schoene, State Entomologist of Virginia, procured for us specimens of living insects and infested wood, for which courtesies we are under obligations.

THE CABBAGE APHIS.*

P. J. PARROTT AND B. B. FULTON.

One of the serious handicaps in the growing of cabbage is the cabbage aphis (*Aphis brassicæ* Linn). In sections of New York where this vegetable is extensively grown the insect is a familiar pest, which seldom fails to make its appearance each year in most plantings; while in occasional seasons it develops to great numbers and becomes very destructive. It is the common practice with most farmers to allow the cabbages to take chances with the aphis, which has proven both uncertain as well as expensive in its results. Experiments by this Station during recent years have demonstrated that the losses occasioned by the pest may be largely reduced, if not prevented, by timely spraying. This circular has been prepared in order to give growers a few concise directions on the protection of their plantings by this means.

DESCRIPTION OF INSECT AND LIFE HISTORY.

The eggs of this insect are laid in the fall, principally during October and the early days of November, in crevices and de-

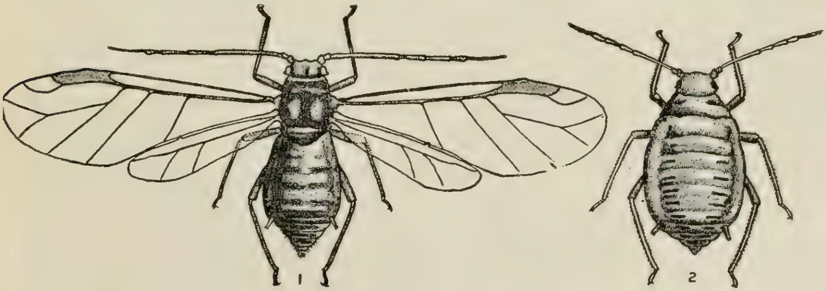

FIG. 35.— WINGED (1) AND WINGLESS (2) FEMALES OF CABBAGE APHIS.

pressions of the leaves, and are usually deposited in the greatest numbers upon the under surfaces. These eggs are minute, oval bodies about one-fortieth of an inch in length and are pale yellow or yellowish green in color, usually becoming black within a few days after being laid. Eggs hatch early in the spring, according

* Reprint of Circular No. 30, June 15.

to seasonal conditions, but usually during April. The aphids that hatch from the eggs are all females, and when fully developed they give birth to living young aphids which become asexual females. These mature in ten to fourteen days and in turn give birth to many young. In seasons favorable to the insect the numbers of the lice increase rapidly, and in a short period of time the leaves of the plants become thickly covered by the greyish-green creatures. At varying periods winged females make their appearance, which seek other plants, and thus distribute the species through the entire field. In the autumn the sexual forms develop, which deposit eggs, thus completing the life cycle of the pest.

The aphis is a sap-sucking insect and subsists on the juices of the cabbage. The effects of the feeding of large numbers of this species are either to dwarf or to kill the plants, which result in the reduction of the weight and numbers of marketable heads.

IMPORTANCE OF THE APHIS TO CABBAGE-GROWING IN RECENT YEARS.

During the past decade severe outbreaks by this pest have been of frequent repetition. Overwhelming numbers of the aphids appeared in 1903, 1908, 1909, 1910 and again during 1913. During these years there was, in certain sections of New York, a great diminution in crop production, due in large part to shrinkage in yields on account of the attacks by these insects and in part to plowing under the fields of cabbage to avoid taking further chances with the lice.

The outbreak of 1913 was not so severe as some others in previous years, but the injury by the aphis, coupled with the prolonged dry weather, was sufficient to destroy many plantings of cabbage. The lice appeared in great numbers in June before the young plants were well established, and there was no cessation in the multiplication of the insects in most cabbage fields till early September. The rainfall during this period is recorded as the smallest in many years, and because of the slight precipitation the plants grew slowly and proved very susceptible to injuries by the lice. The abstraction of sap by myriads of the insects and the deficiency in soil moisture proved, in most fields, a severe drain on the vitality of cabbage. Many of them died, while the

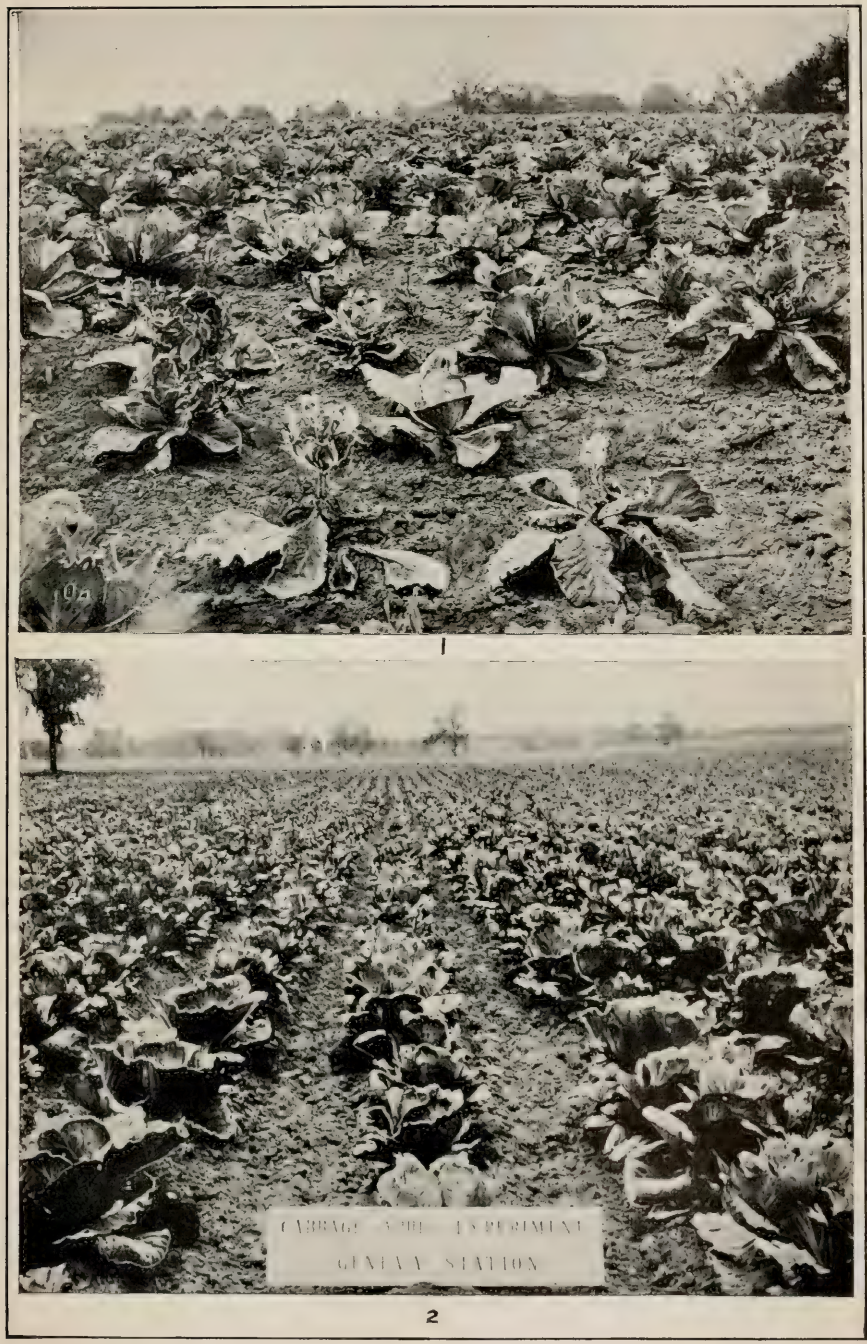

Plate XXXVIII.—Spraying for Cabbage Aphis in 1913.
Conditions on unsprayed plat (1), and on adjoining sprayed plat (2).

Plate XXXIX.—Types of Spraying Outfits Used in the Station's Experiments.

larger proportion of the plants in fields generally grew slowly, forming small heads, which frequently were not of standard size for the market. During August the odor of decaying cabbage was very perceptible in fields in the region of Geneva.

DIRECTIONS FOR SPRAYING.

Spraying Mixtures.

Formula 1, Soap.

Soap	6 to 8 lbs.
Water	50 gals.

Formula 2, Nicotine Extract.

Nicotine extract 40 per ct. (Black Leaf 40)	¾ pt.
Water	100 gals.
Soap	3 to 5 lbs.

Applications of one of the above formulas should be made as soon as the lice appear in threatening numbers and before any of the leaves are appreciably curled. The liquid should be applied under reasonably high pressures, and directed especially into the heart and to the undersides of the leaves of the cabbage, where the lice are usually assembled in greatest numbers. The quantity of mixture to apply and the number of applications required to afford efficient protection depend largely on the extent of infestation and seasonal conditions, as these may influence the duration of the period in which the lice continue to breed in destructive numbers. In plantings that were well infested with lice there was required in the Station tests from 150 to 175 gallons of spraying mixture per acre for one treatment, and during 1913, when reproduction of the aphis continued over a long period, two sprayings gave very efficient results, although the most profitable returns were obtained by three treatments at intervals of ten to fourteen days. In the employment of Formula 2, nicotine extract, which is the more costly of the above mixtures, the expense should not exceed $2.30 for the spray material and $2.40 for labor and team at liberal estimates, which make a maximum cost of $4.70 per acre for one spraying. In cooperative efforts with cabbage-growers in spraying under farm conditions the most successful experiment was conducted at a cost of $4.10 per acre for a single treatment, which was all that was required to protect one field of cabbage under the

adverse conditions of 1913. The chief fault with much of the spraying by farmers against the cabbage aphis is the tendency to hurry with the job and to use the spraying mixture too sparingly, which makes for faulty treatment and is liable to result in disappointing returns.

SELECTION OF SPRAYING MACHINE.

Spraying machines especially constructed for the treatment of large fields of cabbage have not yet appeared on the market, which forces growers to adapt for this purpose the common types of spraying outfits that they possess. The most satisfactory machine is a gasoline-power field potato-sprayer, with the usual spraying spar removed, and equipped instead with two leads of hose with short extension rods bent at the nozzle end to form an angle. Its chief merits are power to maintain uniform pressure and the possession of axles which may be adjusted to the width of the rows, thus reducing injuries to the cabbages by the wheels of the machine during the progress of spraying and in turning on the ends of the rows. In the Station's experiments a "horse-power" or traction field potato-sprayer with a pump of large capacity and equipped with two leads of hose, as with the foregoing outfit, has given excellent satisfaction in fields moderately infested with the lice. By limiting each operator of the nozzles to two rows of cabbages it has been possible to spray practically all of the plants needing treatment. Machines that are more commonly relied on by growers are orchard power-sprayers and barrel outfits mounted on a single- or two-horse truck. These have been used with good effects against the aphis, but with many of them, on account of the width of the axles, cabbages are damaged by the wheels unless at the time of planting provision is made for a suitable spacing of certain of the rows to accommodate the spraying outfits. Traction field-sprayers with fixed nozzles are not well adapted for the treatment of cabbages as many of the insects are not wetted by the application. For spraying a small plat a knapsack sprayer is a convenient and quite satisfactory outfit.

REPORT

OF THE

Department of Horticulture.

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(Connected with Grape Culture Investigations.)

TABLE OF CONTENTS.

REPORT OF THE DEPARTMENT OF HORTICULTURE.

TILLAGE AND SOD MULCH IN THE HITCHINGS ORCHARD.*

U. P. HEDRICK.

SUMMARY.

For ten years this Station has been comparing sod mulch and tillage in apple orchards. This bulletin is a brief account of the experience in the Hitchings orchard, the most notable exception which proves the rule that tillage is the most profitable method for orchard culture under general conditions. The Hitchings orchard is unique among the fruit plantations of the State. Both the lay of the land and the character of the soil differ from those in most orchards; and the trees have been planted, pruned and sprayed, the soil tilled, and the fruit harvested in very original ways. By the "Hitchings method" as applied by its owner, the ground is laid down to sod before or as soon as the trees are set and the grass is cut for a mulch once or twice a season as conditions demand; that is, the orchard remains in sod indefinitely.

In the experimental work three plats are included: Plat A lies on the floor of the valley and is comparatively level. It consists of eight rows of thirty-four trees each, two years old at the beginning of the experiment, the varieties being Wagener, Rhode Island Greening and Sutton. Plat B lies on the lower part of a rolling hill. It contains six rows, each of thirteen trees, the varieties being Alexander, Wealthy and Fameuse. The trees were nine years old when the experiment began. Plat C is higher up on the hillside and consists of four rows, each of six trees of Northern Spy. These trees were ten years of age at the beginning of the experiment. In each plat half the land is in tillage and half in sod. All three plats appear to be well supplied with phosphorus, potash and nitrogen; all are on deep soil; and B and C receive the hillside seepage. All these factors favor the sod-mulch method. All plats were given identical care except in the matter of soil treatment. The tilled plats were plowed early in the spring and cultivated from seven

* Reprint of Bulletin No. 375, March; for Popular Edition see p. 909.

to eleven times, a cover crop, usually of clover, following. In the sod plats was a mixed growth of orchard grass and blue grass. These grasses were mowed once during the summer, usually about the middle of June, and left as they fell, to form the " sod mulch."

Mishaps and slow maturity have prevented crop yields in Plat A. In the other plats, also, the data regarding yields are not as satisfactory as could be desired, but, in brief: The trees in sod bore an average of a little less than four bushels while those in tillage bore a little more than three bushels per tree.

Taking diameter of the tree trunks as the gauge of the two treatments in the bearing orchard, we find that the trees thrive as well under one method as the other. Using the same measure for the trees in Plat A on the floor of the valley we must conclude that those under tillage are doing much the better. Why the difference? Because the hillside seepage furnishes an abundance of moisture for both trees and grass, but in the dryer soil of the valley trees in sod cannot compete successfully with the grass for moisture.

In comparing costs the data are disappointing. The extremes are too far apart. The cost of tilling Plat A was at the rate of $11.22 per acre, Plat B $13.30 per acre, and Plat C $24.33. We paid for cutting grass in plats A and B at the rate of 60 cents per acre and 96 cents per acre in Plat C. The average for the tilled plats was $16.28, for the sod plats 72 cents per acre. These figures bring out the point that the cost of tillage is bound to vary greatly, depending upon land, tools, teams, number of cultivations and other factors. The cost of cutting grass will be more nearly the same for all orchards.

In conclusion, while unquestionably tillage is the best method of caring for the majority of the apple orchards in New York, yet there are particular places, soils and economic conditions under which the Hitchings method of sod-mulching apple trees may be used advantageously:

1st. Orchards on steep hillsides where land would wash badly under tillage may often well be kept in sod.

2d. On land covered with rocks, trees may best stand in sod.

3d. The Hitchings method is adapted only to soils having suitable depth. On shallow soils it will usually prove a failure.

4th. Soils must be retentive of moisture. On land that annually suffers from summer droughts the sod-mulch treatment will almost certainly prove less beneficial to trees than tillage.

Plate XL.— General View of Hitchings Farm: Plat A in Foreground; B and C on Hillside, Center.

5th. Economic conditions may decide the choice between tillage and some mulching treatment, since the cost of caring for an orchard is so much less under the Hitchings mode of mulching than by tillage. Thus a larger acreage in sod may be made to counterbalance a greater productiveness under tillage, thereby bringing the net income to the same level.

INTRODUCTORY.

In March, 1909, this Station published, in Bulletin No. 314, a preliminary report on a comparative test of growing apples under tillage and the Hitchings sod-mulch method. The work of which this first report is an account was carried on in the Auchter orchard a few miles west of Rochester, in the heart of the apple belt of western New York. In this orchard tillage was found to be the better treatment. In the present Bulletin, the second report, the test was conducted in the Hitchings orchard, near Syracuse, under widely different conditions and as we shall see with very different results.

THE HITCHINGS ORCHARD.

The Hitchings apple orchard is unique among the fruit plantations of New York. The trees have been planted, pruned and sprayed, the soil treated and the fruit harvested in very original ways. It has the distinction of having produced in the last fifteen years more prize-winning apples at the annual State fairs in New York than any other orchard in the State. In it originated the Hitchings sod-mulch method of growing apples which made the orchard at once a debating ground as to the merits of the method. The lay of the land and the soil, as we shall see, are also unique. Commendations and condemnations of Mr. Hitchings' methods in the press and on the platform have given the orchard distinction not only throughout New York but wherever apples are grown in the United States.

THE NEED OF A COMPARATIVE TEST.

It early became evident that before there could be a satisfactory interpretation of his results there must be some systematic study of Mr. Hitchings' work. The published and verbal accounts of visitors, founded usually upon a few hours' stay, were seldom adequate and were often distinctly misleading. To obtain a fuller and more

accurate collation of facts than those circulated by casual visitors, the New York Agricultural Experiment Station in 1903 rented for ten years plats for experimental work in the Hitchings orchards. The plats were selected in the autumn of the year named by Professor S. A. Beach, then Horticulturist of the Station, the chief end in view being a comparison of the Hitchings sod-mulch method with the more usual one of tillage and cover crops.

After carrying on the work two years Professor Beach left New York and the work fell into the hands of the writer, the succeeding Horticulturist. The Station's ten year tenure has just passed and this Bulletin is an account of a comparison for a decade, side by side, of tillage and the Hitchings sod-mulch method in the Hitchings orchard.

THE HITCHINGS METHOD DEFINED.

What is the Hitchings method? The term has become the sound-symbol for a mixture of more or less vague practices connected with sod in an orchard: sod pastured with sheep, hogs or cows; sod of blue-grass, orchard-grass, clover, alfalfa, or weeds; sod from which the grass is cut for hay, or cut and piled about the trees, or left uncut; sod supplemented by straw, manure or other by-products; sod the growth of years and sod turned under more or less frequently. This confusion has spread obscurity over much that has been said about the method. Since our experiment is a comparison of tillage with sod mulching as carried on by Mr. Hitchings, his method, now to be described, and none of the modifications suggested above, must be kept in mind.

No easier treatment of the soil in an orchard, short of downright neglect, could be devised than the Hitchings method. It consists in laying the ground down to sod before or as soon as the trees are set and cutting the grass for a mulch once or twice, as conditions may demand, during each summer. The orchard is supposed to remain in sod indefinitely, plowing being detrimental to the formation of the mulch which is essential in the treatment. The cut grass is never removed from the land and until roots and branches utilize the space between plants it is raked and piled about the trees. Many who grow apples in sod supplement the cut grass with straw or similar material as a mulch about the trees — desirable, of course, but not practiced by Mr. Hitchings and not prac-

ticable in the apple regions of New York because it is impossible to get mulching material, since straw or other roughage is not largely grown.

With the particular treatment just outlined, in mind, we pass to two other factors which play equally important parts in the Hitchings orchard — the site and the soil. Indeed, it is impossible to separate these two factors from the treatment in accounting for the results Mr. Hitchings obtained; for all are fundamentals in his success.

OUTLINE OF EXPERIMENT.

SITE.

The Hitchings farm is in the south-central part of Onondaga County, a region noted for dairy products and alfalfa but not conspicuous for its apples. There are few or no commercial orchards within several miles of the Hitchings place and the nearest market for apples is in Syracuse, nine miles away, to which place the fruit is hauled by team. Previous to making a commercial planting of apples Mr. Hitchings had been a dairyman but gave up cows to grow apples, small fruits and vegetables. These statements are made because it is important to know that Mr. Hitchings is a pioneer apple-grower in his locality and that as a pioneer he has blazed a new and original trail in fruit-growing.

The Hitchings farm is in the slightly rolling bottom and on the foothills of a deep valley, poorly shown in the frontispiece because the camera does not give an adequate idea of the height of the hills surrounding. On the level valley-bottom is located Plat A of our experiment, consisting of young trees. The sides of the valley are long, steep hills, the slope, of which the farm is a part, rising to an altitude of 400 or 500 feet in a distance of about a half mile. At the foot of this great hill, and as a part of it, is the main orchard, in which Plat B and Plat C, consisting of older trees, are located. The land lies in too steep an incline in this orchard for convenient cultivation and under constant tillage the soil would wash more or less unless the work be carefully done. The ground, too, is a little uneven whereby some trees are on hummocks and others in hollows. This unevenness accounts in part for the lack of uniformity in the growth and productiveness of the trees conspicuous in the tables given later.

Inhabitants of hilly countries know well that moist, spongy land may be looked for at the foot or on the sides of high elevations of land. The expected happens in the Hitchings orchard, for the land, at all seasons of the year but especially in early spring, contains much water despite well constructed open ditches to carry it away. In fact there are several springs in the orchard, which, however, Mr. Hitchings says, usually dry up in June, and do not begin to flow again until late fall. In a heavier or shallower soil the same amount of water would saturate the land so thoroughly

DIAGRAMS OF PLATS

1. PLAT A.

	Row.	
Sod	1	Wagener.
	2	R. I. Greening.
	3	Sutton.
	4	R. I. Greening.
Tillage	5	Sutton.
	6	R. I. Greening.
	7	Sutton.
	8	R. I. Greening.

2. PLAT B.

	Row.	
Sod	1	Alexander.
	2	Wealthy.
	3	Fameuse.
Tillage	4	Alexander.
	5	Wealthy.
	6	Fameuse.

3. PLAT C.

	Row.	
Tillage	1	Northern Spy.
	2	Northern Spy.
Sod	3	Northern Spy.
	4	Northern Spy.
	5	Northern Spy.

as to make it unworkable. This seepage is one of the fundamental factors in the success of the sod mulch in Plat B and Plat C in the Hitchings orchards. In the plat on level ground, A, all the tests possible to apply at this time show the tilled trees to be the better; on the sidehill, in B and C, the tests show sod mulch to be the better. The chief environmental difference between Plat A and

the other plats is the greater moisture content of the soil in the latter plats, arising from the fact that they receive the seepage from the high hill on whose base they are located whereas Plat A lies on level ground to which the seepage, in summer at least, does not reach.

PLATS.

Two orchards have been mentioned — one on low, level ground in the valley, the other on the lower part of the hill-slope. Plat A, as before stated, is in the valley and plats B and C on the hill-slope. Both orchards were planted before the Station began experimental work with Mr. Hitchings. The trees in the valley orchard were set in November, 1902, the young trees being two years old. The orchard was seeded with a mixture of orchard grass and clover in the spring of 1903. Plat B was put out in the fall of 1894 in a timothy and clover sod from which one crop of hay had been taken. Plat C was planted in the fall of 1893 and also on a timothy and clover sod. The plats are outlined as follows:

Plat A.— This plat includes all of the valley orchard, consisting of 8 rows of 34 trees each, the rows 30 feet apart and the trees 20 feet apart in the row. At the beginning of the experiment these trees had been set two years. Diagram 1 is a plan of the orchard showing the varieties, row numbers, and division of the orchard into sod and tilled sections. The area of each section as computed from the distance apart of trees is 1.87 acres.

The soil in Plat A is undoubtedly Miami loam. It is a dark brown, clay loam of alluvial origin of which the surface soil varies from 8 to 14 inches and is comparatively free from gravel and stone. The subsoil is at least several feet in depth and is a brownish-yellow silt to clay loam. The surface soil contains a small proportion of sand but not enough to prevent crusting over after rains so that it is rather difficult of cultivation — a somewhat tenacious clay.

Plat B.— Plat B is in the lower part of the hillside orchard. The rows are 33 feet apart and the trees 32 feet apart in the row, making .95 acre in each section, one in tillage and one in sod. Diagram 2 shows the varieties, row numbers and cultural divisions. The trees in B were nine years old when the experiment began. Unfortunately two trees died in the early life of the orchard and their places were given to other varieties. Thus, tree 12 in row 2 is Pound Sweet and tree 5 in row 6 is Yellow Bellflower, both varieties

foreign to the experiment and therefore not henceforth to be considered.

The surface of Plat B is somewhat broken, but the main soil type is fairly uniform. The soil is Miami stony loam, shading in places into gravelly loam, exceedingly variable in depth, brown in color and more or less sandy in texture. In places on this plat the soil contains a high precentage of broken rock or shale fragments, especially on its higher portions. The subsoil is of fair depth and consists of a deep brownish-yellow clay loam with a considerable proportion of gravel and shale fragments.

Plat C.— Plat C is up the slope above Plat B. The trees were ten years of age at the beginning of the experiment and are set at the same distances apart as those in Plat B. The area of the tilled and sod plats is .27 acre each. Diagram 3 shows the plan of the plat. The sixth tree in row 3 could not be used and a tree in row 5 had to be substituted.

The soil in Plat C is Miami stony loam. It is not so gravelly as that of Plat B, is somewhat shallower in depth and contains more large stone but otherwise it is very similar.

A mechanical analysis of the soils in these plats was not made but their chemical constituents were carefully studied to see, if possible, under which of the two treatments the soil was most depleted of fertility. Table V, page 526, gives the results of chemical analyses of the soils at the end of the ten-year period. The analyses, it suffices to say here, show the soil to be fairly well supplied with phosphorus, potassium and nitrogen but rather deficient in lime.

That these plats are not suitable for accurate experimental work must be admitted at once. The defects are many. Thus, the trees in B and C are too few, the plats are of unequal areas, there are too many varieties, the trees in the several plats are of different ages, the land on the hillside is uneven and the soil is not uniform. But better plats could not be laid out in the Hitchings orchards and it was much desired that a comparison of sod mulch and tillage be made here where the mulch system had become most prominent in New York.

MEASURING THE RESULTS.

When the work in hand was turned over to the writer the plan of procedure had not developed further than the taking of notes on the yields and expenses of the several plats. As the project took

shape it became more and more apparent that small opportunity was offered for determining fundamental facts regarding the effects of sod mulch and tillage on trees for, beside the defects in the material mentioned in the preceding paragraphs, mishaps of various kinds, as the death of trees, began to occur.

For the reasons given it was early decided that crop performance and tree growth were to be the chief tests in the comparison of the two methods of culture as being the most satisfactory gauges under the conditions. After all, yield of fruit and growth of tree are the ultimate criteria of methods of management and if extended over sufficient time should be satisfactory to fruit-growers and ought to convince experimenters of the relative values in practice of the methods. These gauges may tell which is the better method, but they tell practically nothing as to why one method is better than another. The work in hand, then, is more demonstrational than experimental.

In this discussion of results, then, yield of fruit and growth of tree are to furnish chief evidence. Since cheapness is one of the great merits of the Hitchings method, statements of expenses must be compared. The writer feels that to attempt to go further is to raise more questions than can be answered — to stir up more hares than can be run down.

It remains to be said, before taking up the data, that while the care of the experimental plats had been directed from the Station, the work has been in the hands of Mr. Hitchings — done in his way and at his discretion. The records of yields and expenses were kept by him, being turned over to the Station at the end of each season. Perhaps this is the best place to express appreciation of the zeal and enthusiasm which Mr. Hitchings has shown in carrying on these experiments. If the work at any time has suffered, it is because a very busy man could do no more. If in places the data lack fullness, the same reason stands.

PROGRESS AND RESULTS OF EXPERIMENT.

TREATMENT OF PLATS.

The trees in the several plats under comparison have received identical care in all orchard operations excepting soil treatment, which has been as follows:

Sod plats.— The sod was established, as we have seen, before the experimental work was begun. It consisted in 1905, when the writer first saw it, of a good sward of orchard grass with some blue grass, in which was a rather diversified flora of the weeds commonly found in meadows; as, the docks, wild carrot, ox-eye daisy, mullein, fleabane and the plantains, with peppermint in the wettest places in the hillside orchard. In the ten years the sod-flora has varied but little. The character of the sod is shown in the several illustrations in this bulletin. The grass was mowed on the following dates:

TIMES OF MOWING.

Plat A.	*Plat B and Plat C.*
1904, June 17 and August 20.	1904, Once — date not given.
1905, " 15 " " 9.	1905, " " " "
1906, " 14.	1906, July 6.
1907, " 14.	1907, June 26.
1908, " 1.	1908, July 17.
1909, Once — date not given.	1909, Once — date not given.
1910, " June 20.	1910, June 10.
1911, " date not given.	1911, Once — date not given.
1912, " " " "	1912, " " " "
1913, " " " "	1913, " " " "

In Plat A the mowed grass in 1904 was in part sold for hay, but was piled about the young trees in all of the succeeding seasons. The grass was put under the trees in B and C the first three summers but not afterwards, since the roots of these older trees at this age began to meet in the spaces between rows. It is hard to estimate the amount of hay the cut grass would have made per acre in the two orchards, but an average of one and one-half tons would probably be fair.

Tilled plats.— The following is a memorandum of the treatment of the tilled plats:

TREATMENT OF TILLED PLATS.

1904. All plats plowed in May and cultivated during the season seven times. Cover-crop of clover sown about August 1st; trees hoed three times.

1905. All plats plowed in May and cultivated seven times thereafter. Cover-crop of clover sown about August 1st; trees hoed five times.

1906. Plats plowed April 24–25 and Plat A cultivated nine times and B and C eight times. Trees in A hoed four times and in B and C three times; cover-crop of clover sown August 1st.

1907. Plats plowed April 30–May 2; A cultivated ten times and B and C eight times; trees in all plats spaded about once and those in A hoed about once; cover-crop of clover sown August 3.

1908. Plats plowed April 22–23; A cultivated twelve times and hoed three times, B cultivated ten times and C eight times; cover-crop of crimson clover sown August 7 in A and on the 8th in B and C.

1909. Plats plowed April 27–28; A cultivated eleven times and trees hoed twice; B and C cultivated ten times; cover-crop of crimson clover sown August 23.

1910. Plats plowed April 24–26 and B cross-plowed May 30; A cultivated eleven times; and B and C seven times; cover-crop of wheat sown in A September 15.

1911. Plats plowed April 24; A cultivated twelve times and B and C eight times; trees in B hoed about once; no cover-crops this year.

1912. Plats plowed May 2 and 3; A and B cultivated eight times and C seven; cover-crops of wheat sown September 12.

1913. Plats plowed April 23 and 24; all plats cultivated five times.

The cultivation between rows one way was at all times most thorough. Many fruit-growers will say that the expense of cultivation, as shown by the number of times it was done and by the financial statement in Table IV, was much above that of the average tilled orchard. Strips of sod from ten to twelve feet wide were left in the tree rows in all of the plats. Mr. Hitchings maintained that cultivating could not be done between trees in the row without danger to the trees and that the roots were out beyond the sod strips at this time. Plates XLIV, XLV, XLVI, show the character of the cultivation.

DISASTERS.

Cherished projects seem doomed most often to disaster. Plat A in the Hitchings orchard is one of these. As the largest of the plats and because lay of land, soil, varieties, and, in fact, all conditions were most favorable at the beginning of the experiment, this plat was given the most watchful care. " But who can turn the stream of destiny?" Excessive cold in the winter of 1903–04, the first year of the experiment, killed a number of young trees in Plat A outright, so weakened several others that they died later, and unquestionably checked the growth of all. As the trees died their places were filled but these replantings could not be used for the tests under way. Out of the 272 trees in this plat, 52 were sooner or later discarded because of injury the first winter.

Seemingly through some malevolent influence, but probably because of unsuitability of valley land to fruit-growing in this region, the trees in Plat A show a strong aversion to bearing apples. Ten seasons passed without a crop of apples — only scattered specimens. The trees began their eleventh summer white with bloom and all seemed favorable for at least one test crop during the tenure of our experiment. But in the end, as at the beginning of the test, disaster came in a night and through the same agency — cold. The freeze in blossoming time, 1913, played havoc with the setting fruit and from

what promised to be a full crop the writer picked one apple at harvest time. The plats in the hillside orchards escaped both freezes.

The trees in all of the plats have had their full share of the usual insect and fungus troubles but so far as could be seen from careful observation, though not special study, pests were as numerous and troublesome in one section of the plats as another, with the single exception of blight. The Alexanders, always susceptible to blight, suffered more from this disease in the tilled than in the sodded sections. Seven trees under tillage were killed by the blight in Plat B. Red-bugs came in devastating numbers in B and C in 1905 and have reappeared every year since, preventing the division of the crops into market grades in accordance with size, since injured fruits, no matter what their size, had to be put into seconds or culls. In 1913, however, this pest was kept under control by spraying with Black Leaf 40. In two seasons the apple maggot was reported by Mr. Hitchings as having prevented a proper grading of all varieties in accordance with size.

TABLE I.—AVERAGE YIELD, IN BUSHELS OF APPLES PER TREE, ON SOD AND TILLED LAND.

PLATS B AND C, HITCHINGS ORCHARD.

YEAR.	SOD.				TILLAGE.			
	Alexander	Fameuse	N. Spy	Wealthy	Alexander	Fameuse	N. Spy	Wealthy
1904	.47	1.02	.46	3.14	.61	1.02	.21	2.56
1905	.25	2.69	.38	1.35	.41	1.85	.21	.87
1906	.04	1.23	.92	4.46	.04	3.42	1.75	4.05
1907	.04	3.96	2.08	5.13	.39	1.55	.75	2.20
1908	.38	2.12	4.33	3.31	.22	2.25	3.08	4.29
1909	1.54	11.04	.42	8.17	.61	6.17	2.17	3.77
1910	1.62	1.00	5.25	5.04	.61	2.25	3.00	7.81
1911	4.62	13.62	3.17	6.42	5.33	10.92	5.42	5.15
1912	5.44	9.88	5.08	6.83	2.25	9.19	3.91	10.86
1913	3.97	14.46	5.17	7.33	2.83	6.17	4.35	2.63
Average	1.84	6.10	2.73	5.12	1.33	4.48	2.49	4.42

SOD TILLAGE.

PLATE XLI.— YOUNG TREES IN PLAT A, SECOND YEAR OF EXPERIMENT.

Plate XLII.— Northern Spy Tree Typical of Those in B and C at Beginning of Experiment.

TILLAGE. SOD.

Plate XLIII.— Plat C at Beginning of Experiment.

TILLAGE SOD

Plate XLIV.— Plat C in 1913.

Plate XLV.— Plat B in 1913: Upper Half, Tillage; Lower Half, Sod.

PLATE XLVI.—PLAT A: UPPER HALF, TILLAGE; LOWER HALF, SOD.

CROP PRODUCTION.

In the long run crop production is of course the best measure of merit in a method of orchard management. Ten years, it might be thought, is a sufficiently long period to make yield of fruit almost an absolute test as to which of two methods is the better in a given orchard. Happily the ten years during which this work has been in progress have been seasons of abundant apple harvests. Crops have been good, bad and indifferent with some varieties, but total failure has not had to be recorded with any variety in the two bearing plats. Table I gives the yields of fruit for the ten years on plats B and C. The yields on Plat A may be briefly summarized as follows:

Yields in Plat A.— A glance at the chart of Plat A shows three varieties, of which we are considering but two, Rhode Island Greening and Sutton; because the third, Wagener, was under sod only. The Rhode Island Greenings bore no fruit until 1911 when the sodded trees bore one bushel of second-class fruit and the tilled trees a half bushel of culls, the crop in both cases having been ruined by insects. For some reason the sodded Greenings bore no apples in 1912, while those under tillage bore twelve bushels. In 1912 Sutton in sod bore one bushel; under tillage two bushels. These figures mean but little, probably being accidental variations.

Yields in plats B and C.— In the table submitted only the total quantity of fruit is given. It is doubtful whether any other figures than those of total yield are worth considering; for Mr. Hitchings' gauge of seconds and culls for his particular and peculiar market is different from that of most apple-growers, depending for one thing more largely upon color. So, too, red-bug was a disturbing factor, causing many seconds and culls in apples large enough to go as firsts. And, lastly, Mr. Hitchings' method of harvesting early apples over a somewhat lengthy period by allowing the fruit to drop or by shaking it on the ground would certainly cause more poor fruit in the tilled than the sod sections; thus we have the statement from Mr. Hitchings, " Harvesting the crop of apples under tillage is very unsatisfactory on account of the dirt which clings to the fruit as it drops from the trees. This is entirely avoided in the sod section." It should be added that another reason for this method of harvesting was that on the tilled land the apples were left until they dropped, with the hope that they would color better.

Summarizing the figures, we find that Alexanders growing in sod produced an average of 1.84 bushels per tree during the ten years, under tillage 1.33 bushels. Fameuse in sod bore an average of 6.1 bushels per tree, under tillage 4.5 per tree per year. Northern Spy in sod bore 2.7 bushels, under tillage 2.5 bushels per year. Wealthy in sod produced 5.1 bushels per year, under tillage 4.5 bushels. Averaging the figures for four varieties we find that the trees in sod, ten years set at the beginning and twenty at the end of the experiment, bore an average of a little less than four bushels per tree, while those in tillage bore a little more than three bushels per tree. To be exact, the difference between sod and tilled plats was four-fifths of a bushel per tree per year in favor of the sod mulch.

Taking, therefore, the difference in total yield of fruit between the two plats as the measure of value of the two treatments, the sod-mulch method is shown to be somewhat the better way of handling apple trees under the conditions prevailing in the Hitchings orchard.

NUMBER AND SIZE OF APPLES.

Year in and year out there was little difference in size between the apples in the two sections. In 1904 and 1905 counts were made of equal weights of varieties from the several sections, the results showing in 1904 a slight increase in size for the apples from the tilled sections. In 1905 a similar count showed the fruits from the sod plats to be a little the larger. In neither year were the differences beyond the range of accidental variation. In no season was it possible to determine, with the eye, differences in size in apples from tilled and sodded trees. Apples attain more than average size in the Hitchings orchards and probably less of these ten crops than in most orchards went into seconds and culls because of small size.

Size is worth considering, in these experiments, only as it has a bearing upon marketable quantity. The value of the whole crop was affected little, or not at all, by size. But in studying the table showing the amounts of fruit for the different years the question naturally arises: Is the increased quantity in any year or for any variety due to more apples or are the apples larger? We have no data to submit to settle this question but it was very apparent, in the years when a variety in one section gave a greater quantity of fruit than the same variety in the other section, that it was chiefly because of a greater number of fruits. An examination of Table I shows

an interesting alternation in most of the varieties — one year the variety produced most fruit in sod, the next under tillage. No reason appears for this biennial-bearing habit of varieties in which the off year for sod was the bearing year for tillage.

COLOR OF FRUIT.

It needs hardly to be said that the apples from the sodded plats were much more highly colored and therefore much more attractive in appearance than the fruit from the tilled plats. It may be laid down as a universal rule that sod heightens the color of apples in the orchards of New York. Another rule that very generally holds in this State is that the conditions which produce high color are antagonistic to yield of fruit and to growth of tree. The figures presented in Table I are not in accord with this rule as it applies to yield of fruit, but those showing the relative growth of trees, Table II, are in exact accord.

The correlations between color and quantity and color and growth of tree need further consideration, best given by way of illustration. Every orchardist of experience in this region knows that girdled, wounded, diseased, decrepit, poorly nourished, or somnolent trees bear more highly-colored fruit than healthy, normal trees growing near them. In this day of almost universal tillage in commercial apple orchards in New York, one of the common questions is, How can I check growth and obtain more highly-colored fruit? High color in red apples is as trustworthy an indication of ill-being in a tree as high pulse or high temperature in a human being — so dependable that its occurrence in any method of growing apples enables us at once to say that is is purchased at the expense of health or vigor of the tree.

The red of the several varieties under tillage and in sod varied a good deal with the season. The trees in sod ripen their fruit somewhat earlier than those under tillage and if in the last part of the season the weather is sunny and propitious for the coloring of apples, the tilled fruits, because they remain a little longer on the trees show less marked difference in color than otherwise.

The apples on the tilled plats are exceptionally well colored for tilled fruit because, possibly, of altitude, the soil, or of some unknown factor, or some combination of conditions which often gives tilled apples from the Hitchings farm a color and finish rivaling the best

western fruit though seldom as beautifully colored as the same variety from near-by sodded trees.

MATURITY AND KEEPING QUALITY OF THE FRUIT.

As stated in the last paragraph the fruit on the plats in sod ripens a little earlier, the difference being from a few days to two weeks, depending upon the season and the variety. In a wet, cool autumn there is but little difference in time of ripening, but if the weather be dry and warm the difference is considerable. The earlier-ripening Alexander and Wealthy mature more nearly at the same time in the two sections than the later-ripening Fameuse and Spy.

Little can be said of the keeping quality in common storage of the apples in this experiment. None of the varieties are late keepers and in the tests we were able to make, the quantities were so small and the disturbing factors so many — such as lack of data as to picking, sample sent selected for exhibition purposes, quantity not sufficient for a fair test — that we are not warranted in making definite statements. Mr. Hitchings reports that with him "the apples from the sod plats hold up much better than from those under tillage."

TREE GROWTH.

What effect have the two methods had on the growth of trees? In a ten-year period it would be expected that the method under which most fruit was produced would give greatest growth in trees. Yet such is not the case, from the figures we have to present. For, whereas our figures show the sodded trees to have yielded somewhat larger crops of fruit the data show the trees to have made much the same growth under the two treatments in the bearing orchard and a much larger growth under tillage with the young trees.

Thus, we find from a consideration of Table II, giving diameters, that in Plat A the Rhode Island Greenings and the Suttons average more than one inch each greater diameter than the trees in sod, a very considerable greater growth for trees but eleven years set. In Plat B the Alexanders in sod have made a gain of a little over an inch in diameter more than those under tillage, but this evidence should be ruled out because eight of the original thirteen tilled trees died and some of the remaining five were badly cut back because of blight. The Fameuse and Wealthy trees in this plat are almost

at a stand-off with the odds a little in favor of the trees in sod. The tilled and sodded trees of Northern Spys in Plat C made almost an identical average increase in diameter in the ten years, there being but the insignificant difference of .01 of an inch. The diameters, it should be said, were taken at one foot from the ground.

Table II.— Diameters of Apple Tree Trunks on Sod and Tilled Land.
PLAT A, HITCHINGS ORCHARD.

Year.	Sod.						Tillage.					
	R. I. Greening 45 Trees	Sutton 21 Trees	Alexander 12 Trees	Wealthy 11 Trees	Fameuse 13 Trees	N. Spy 12 Trees	R. I. Greening 55 Trees	Sutton 28 Trees	Alexander 5 Trees	Wealthy 13 Trees	Fameuse 11 Trees	N. Spy 11 Trees
	Ins.	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*
1904.....	.87	.75	3.58	3.24	4.70	4.45	.723	.800	4.02	3.27	4.23	4.27
1913.....	5.16	4.73	8.01	6.42	10.38	8.11	6.103	6.000	7.37	7.18	9.02	7.92
Gain.	4.29	3.98	4.43	3.18	5.68	3.66	5.38	5.20	3.35	3.91	4.79	3.65

Gains for Sod.

Fameuse..................	.89 inch.
Northern Spy.............	.01 "

Gains for Tillage.

R. I. Greening.........	1.09 inches.
Sutton.................	1.22 "
Wealthy...............	.73 "

Should we take growth in diameter of the tree trunk as the sole gauge of the value of the two treatments in the sidehill orchard, we should have to say that the trees thrive seemingly as well under one method as the other. Using the same measure for the trees on the floor of the valley, we must conclude that the trees are doing much the better under tillage. Why the difference? We answer at once, because the soil is deep enough to give the trees a much larger root-run on the hillside, whereby they get away from the grass, and because the hillside seepage furnishes an abundance of moisture for both trees and grass. In the comparatively shallow and dry soil of the valley, trees and grass compete in the sod for food and moisture and the trees suffer.

There is a close agreement in the growth of parts or organs of trees as affected by different treatments or conditions and when, as with these trees, trunk diameters can be given for a series of seasons, there is little need of other measurements to show vigor and health. There

might, however, be some difference in form of top whereby the trees, though larger in trunk diameter, would be possibly less desirable orchard plants. Spread of branch and height of tree ought to give all of the data in regard to form of top needed by a fruit-grower. It would have been too difficult a task to take these dimensions in the twenty-year-old trees in Plat B and Plat C and we can therefore but say that gauged by the eye, height of tree and spread of branch in the trees in these plats increased very closely in accordance with the increase in diameter of trunk. Plates XLIV and XLV show at least that the differences in these particulars are not very marked.

It was easier to measure the height and spread of the young trees in Plat A. Table III gives these dimensions and Plate XLVI shows them compared in photographs. The figures in the table need no amplification. They show a very material increase in both height and spread of branches for tilled trees.

TABLE III.— HEIGHT AND SPREAD OF APPLE TREES ON SOD AND TILLED LAND. PLAT A, HITCHINGS ORCHARD.

	SOD.		TILLAGE.	
	R. I. Greening, 45 trees.	Sutton, 21 trees.	R. I. Greening, 55 trees.	Sutton, 28 trees.
Height in feet	10.01	11.07	10.11	12.38
Spread in feet	11.8	7.64	13.10	8.52
Gain in height	....	....	.10	1.31
Gain in spread	....	....	1.3	.88

UNIFORMITY IN TREES AND CROPS.

One of the best tests of any orchard treatment is uniformity of trees. In a plantation of trees of the same age uniformity is a financial asset. It is essential in good orcharding that trees bear annually, that the fruit be uniform in size and color, that the crop be well distributed on the tree and that the trees in the orchard bear approximately the same quantity of fruit. In growth of trunk and branches and of foliage there should also be as few departures as possible from the normal.

In the first report on sod mulch and tillage published by this Station, in all of these respects the honors went to the tilled trees. As regards the crops of fruit in the two kinds of culture in the Hitch-

ings orchards convincing data are lacking, but in tree growth, as could be seen by the eye, the trees in sod are less uniform in most of the varieties. In Plat A, in particular, the diameters, the heights and the spread of branches are all less uniform in the sod than in the tilled plat. Plates XLV and XLVI, in which the two methods of culture are illustrated, show to the eye this greater uniformity of tilled trees.

For this superiority of tilled trees in uniformity we have the same reasons to offer as those set forth in the bulletin on the Auchter orchard; namely,[1] "No matter how uniform the sod there will be areas well grassed and areas poorly grassed; areas in which there is an admixture of some plant not to be found in the same quantity elsewhere. Now this lack of uniformity of environment cannot but bring about ununiformity in the trees themselves. On the contrary, tillage is conducive to a uniform environment as it secures surface uniformity of the field, equalizes the depth of soil, and tends to evenness in the amount and availability of moisture and food. One of the reasons for cultivating any crop is to secure an equally vigorous growth over the entire area cropped."

FOLIAGE.

The health and vigor of trees are readily determined in the growing season by the color of the foliage. The darker the green of the leaf the healthier and the more vigorous the tree. Most fruit-growers will agree that there is no test of the well-being of an orchard, outside of actual crop performance, more dependable than the color of the leaves. In determining the value of the two methods of culture under consideration, then, much weight must be given to leaf-color, keeping in mind, however, that there is the possibility of trees growing too vigorously for best fruit production.

In determining color of foliage reliance must be placed on observations by the experimenters, since there is no ready method of color measurement. The records of the various observers from the Station sent to the Hitchings orchard from time to time during the several seasons of our tenure show that at nearly every visit the color of the foliage of the tilled trees was darker and richer, indicating greater vigor than in the sodded trees. In no case was the foliage of the

[1] N. Y. Sta. Bul. 314 : 103. 1909.

trees in sod a darker green and in the few instances in which differences could not be discerned, the observation was either made very early in the season, or, and this is significant, after or during a period of wet weather. In particular, this was true of the young trees in Plat A. Thus, the color of the foliage is in agreement with the diameter of the trunk, the spread of branch and the height of head, in attesting the greater vigor of tilled trees.

A fact, possibly of little practical importance but quite suggestive, is that the tilled trees usually blossomed, and so far as our records go, always leafed-out from one to several days in advance of the trees in sod. This is in accord with the behavior of the trees under the two methods of treatment in the Auchter orchard.[1] In the latter orchard temperatures taken throughout one summer showed that the tilled land was warmer than the sodded land, from which the assumption was made that the trees bloomed and leafed earlier in the tilled land because the soil was warmer. If the supposition for the Auchter orchard is correct, we may assume that the tilled land in the Hitchings orchards is warmer.

Observations on the time of dropping of leaves in the several plats could not be made by observers from the Station but from the following quotations from reports made by Mr. Hitchings it seems that foliage on the sodded trees dropped soonest:

November 14, 1904.— " The cultivated trees are still hanging on to their leaves."

October 31, 1905.— " Foliage on tilled plats dark green in color, very few leaves shed; on sod plats the foliage has almost all turned yellow and one-half or more is shed."

October 29, 1907.— " The foliage on the cultivated plats has held a good color up to date."

November 2, 1908.— " The foliage held better on the tilled plats; kept green until destroyed by frost."

In the reports for years other than the four from which the quotations given were taken, the time of the leaf-fall is not noted. There is an advantage and a disadvantage for trees retaining foliage late in the season without loss of color. When foliage takes on autumn colors and drops early, the growing season is cut short and the trees probably lose somewhat in growth and vigor. In late-ripening varieties there is also, no doubt, some loss in size of fruit and, since

[1] N. Y. Sta. Bul. 314 : 103. 1909.

maturity of leaves must coincide more or less with the ripening of fruit, we should expect, as has been the case in the Hitchings orchard, that the fruit would ripen earliest on the trees dropping their leaves soonest. On the other hand the lighter tints of maturing leaves and the earlier dropping of foliage give conditions under which the apples take on higher colors.

SURFACE WASH.

Plats B and C, it will be remembered, are on a fairly steep hillside. Since surface wash is one of the chief objections to tillage on hillsides, the tilled plats have been under close observation to see what harm might be done by washing. In none of the reports of any of the many visits made by various members of the Station staff, nor in any of the reports from Mr. Hitchings, is it shown that the tilled plats have suffered harm from washing. It must be said, however, that the cultivated plats are so narrow that washing would hardly take place as it might do on a wider area.

This opportunity cannot be permitted to pass without stating the writer's opinion that the danger from surface washing on hilly lands in New York is greatly exaggerated. Torrential rains are comparatively infrequent in this State, orchard lands usually are more or less stony and stones impede washing, and June and July, the months that orchards are tilled, constitute but a short time, at a season of the year when rains are all too few, for washing to take place. A rather wide observation in the fruit-growing regions of New York has not shown many tilled orchards that wash badly. After several more years in observing orchards on hillsides in this State we can reiterate with emphasis the following statements made in Bulletin 314, page 112, in regard to washing on orchard lands.

" The land in the Auchter orchard is rolling, though nowhere are the slopes steep. In this respect it is a fair average of the apple orchards of western New York. At no time has there been any harmful surface wash in either of the two plats and we have not, therefore, had an opportunity to observe in this orchard the influence of cultivation on surface wash. Since tillage is objected to on hilly ground because it is supposed to favor surface wash, it may not be out of place to give observations from elsewhere in this regard.

" In all but the steepest locations in the climate and on the soils of New York, embracing practically all sites upon which trees can

be sprayed, harvested and pruned with sufficient ease to make fruit-growing profitable, proper cultivation may be made an efficient means of lessening the washing of land. Whatever contributes to the porosity of the soil prevents washing. It is obvious that cultivation makes a soil granular and porous. Plowing and tillage to check surface wash on steep slopes should be as deep as possible; furrows should run at right angles to the slope to impede the fall of the water; in some cases open furrows and ditches having a very gentle fall can well be maintained. If the above means of stopping surface wash be supplemented by cover-crops, which check the wash at the season when the rainfall is heaviest, it can be said that almost any land upon which it is practicable to grow fruit can be cultivated. Such deep-rooting cover-crops as the clovers and cow-horn turnips are of great value on land that washes because they form root tubes which help to take care of the water. Artificial drainage is sometimes necessary on hillsides to prevent land from becoming waterlogged which of course would favor washing. There need be little solicitude about surface wash on most of the fruit lands of New York if proper precautions are observed where it is menacing."

COST OF THE TWO METHODS.

Of the tests to determine the value of methods in commercial fruit-growing, the cap sheaf of the shock should be the cost of production. The curt dictum " the weakest goes to the wall " applies in apple-growing as well as to other financial enterprises. But unfortunately when we came to apply this test to the two methods under comparison, expectant as we have been, the data are most disappointing. The extremes are so far apart, not only between the two treatments, but between the different plats under the same treatment, that the figures are at once seen to mean but little. Let us run over the summaries as found in Table IV, the amounts being those charged the Station for the work by Mr. Hitchings.

A glance at the acre averages shows that it has cost the Station \$.60 per acre annually to have the grass cut in Plat A and Plat B and \$.96 for the same work in Plat C. The cost of cultivation per acre per year was \$11.22 for A; \$13.30 for B; and \$24.33 for C. The average for the sod plats is \$.72 per acre; for the tilled ones \$16.28 per year. We can well believe that grass can be cut for \$.72 per acre and that the average, though a little low, might pass for the

State, but we greatly doubt if there are many or any fruit-growers in New York who yearly pay $16.28 per acre for the cultivation of their orchards. The same operations in the Auchter orchard for the same ten years cost $.80 annually per acre for cutting the grass and $7.39 per acre for cultivation.

Table IV.— Comparative Cost of Sod Mulch and Tillage Methods of Handling Apple Orchards.

HITCHINGS ORCHARD.

Year.	Sod.			Tillage.		
	Plat A.	Plat B.	Plat C.	Plat A.	Plat B.	Plat C.
1904	$2 60	$0 50	$0 30	$30 53	$12 36	$7 25
1905	2 60	1 10	30	21 15	13 20	4 70
1906	1 00	50	20	27 38	18 25	11 44
1907	1 10	50	30	22 70	17 05	9 85
1908	90	50	30	20 95	14 78	5 26
1909	60	40	20	25 00	18 10	7 10
1910	60	80	25	24 50	9 80	4 40
1911	60	40	25	15 10	8 30	5 60
1912	50	50	25	14 20	9 30	6 10
1913	75	50	25	8 40	5 20	4 00
Average	$1 13	$0 57	$0 26	$20 99	$12 63	$6 57
Acre average	60	60	96	11 22	13 30	24 33

The differences in cost per acre of tillage are not due to prices of labor since the rate per hour in the two orchards averaged the same. The cost of the operation in the two orchards varied somewhat, of course, because of the diverse character of the soils and of the lay of the land — the Auchter orchard being the easier to cultivate. Then, too, the smallness of the plats has made cultivation more expensive in the Hitchings orchard, and, lastly, whereas the average number of cultivations which Mr. Auchter considered sufficient to keep the land in good tilth was seven, Mr. Hitchings thought his land required nine cultivations. This brings out the point that the cost of tillage is bound to vary greatly depending upon land, tools, teams, number of cultivations and other factors, whereas the cost of cutting grass in the orchard will be approximately the same in all parts of the State.

EFFECTS OF THE TWO TREATMENTS ON THE SOIL.

It is important to know how the two treatments have affected the food and humus content of the soil in the three plats. Table V shows the chemical analyses of soils in the sod and tillage sections of the plats at the close of the experiment. Only the columns in the table showing total carbon and nitrogen content need be considered in the present inquiry, the amounts of other substances being given chiefly to show the character of the soil. None of the constituents of the soils, excepting the two selected, in quantities as large as the analyses show them to exist, may reasonably be expected to have been appreciably changed in the ten years of this experiment.

TABLE V.— ANALYSES OF SOIL FROM HITCHINGS ORCHARD.

POUNDS PER ACRE IN FIRST SEVEN INCHES.

LOCATION.	P_2O_5	P	CaO	Ca	MgO	Mg	K_2O	K	$CaCO_3$	CO_2	Total carbon.	N.
Plat A:												
Sod....	4,440	1,940	12,600	9,000	22,800	13,800	46,000	38,200	1,860	840	50,200	5,800
Tilled...	4,720	2,060	8,800	6,400	11,200	6,800	48,400	40,200	1,760	780	48,000	5,400
Plat B:												
Sod....	4,620	2,020	10,800	7,600	18,600	11,200	55,600	46,200	1,560	700	63,400	7,200
Tilled...	4,260	1,860	14,800	10,600	23,200	14,000	52,400	42,400	1,220	540	46,000	5,800
Plat C:												
Sod....	3,900	1,700	16,600	11,800	13,200	8,000	36,600	36,600	1,740	780	74,000	6,600
Tilled...	2,940	1,280	12,800	9,200	22,800	13,800	47,600	47,600	1,340	600	22,000	3,000
POUNDS PER ACRE IN SECOND SEVEN INCHES.												
Plat A:												
Sod....	2,520	1,540	9,600	6,800	21,600	13,000	49,600	41,200	1,520	680	33,600	4,200
Tillage..	2,580	1,560	7,600	5,400	15,000	9,000	......	......	900	400	26,800	3,600
Plat B:												
Sod....	4,400	1,920	11,400	8,200	17,200	10,400	55,200	45,800	1,660	740	52,400	6,200
Tillage..	4,580	2,000	12,400	9,000	22,200	13,400	......	......	1,260	560	......	5,600

The amounts of carbon found in the analyses of tilled and sodded soils indicate that there is considerably less humus in the tilled land than in that kept in sod. The same is true of nitrogen. Whether the quantities of humus and nitrogen found in the tilled land are sufficient for the needs of the apple we do not know. Neither do we know whether humus and nitrogen are increasing or decreasing in the. several plats, since, unfortunately, analyses were not made at the beginning of the experiment. It may reasonably be assumed, however, that under the action of tillage and with the comparatively sparse cover crops turned under in the tilled plats, both humus and nitrogen have decreased more than is good for apple

land. This leads to the statement of a conviction that has been forming in the writer's mind for several years past. Namely, it is becoming more and more apparent that cover crops alone in many cases are not sufficient to supply tilled orchards with the humus and nitrogen, humus in particular, that trees need and that the deficiency must be made up by an occasional application of stable manure, or by occasionally keeping the orchard in a clover sod for a season.

INFERENCES FOR NEW YORK APPLE-GROWERS.

From the behavior of the Hitchings orchards, New York apple-growers may infer that there are particular places, soils and economic conditions under which the Hitchings method of sod-mulching apple trees may be used advantageously. Since the prerequisites for the success of the method, as indicated by the Auchter and Hitchings orchards, are not very generally found in this State, the situations in which sod may be given preference over tillage should be set forth with exactitude. These are:

1st. *Orchards on steep hillsides where land would wash badly under tillage may be kept in sod.*— As we have tried to show in the paragraphs on surface washing, page 523, cultivation may be so managed that there are few commercial apple orchards in New York in which cultivation need be prevented by soil erosion. It is probable that clover or some other legume might be substituted advantageously for the blue grass and orchard grass of the Hitchings method where sod is desired to keep water from wearing the land away.

2d. *Land covered with rocks, whether steep or not, must often be kept in sod because of the impossibility of tilling.*— There are not a few such orchards in New York.

3d. *The Hitchings method is best suited to soils having considerable depth.*— It is adapted only to soils in which grass roots and tree root do not come in too intimate contact and too direct competition for food and moisture. The commercial apple orchards of New York are at present on lands the top soil of which averages less than a foot in depth. On these shallow soils the Hitchings method will prove a failure.

4th. *Soils must be retentive of moisture.*— To sustain trees at their best under the Hitchings method, soils must not only be deep but must be very retentive of moisture, or have the water table compar-

atively close to the root run of the trees, or, as in the case of the orchards under discussion, must be fed by seepage from higher ground nearby. On land that suffers from summer drouths, this sod-mulch treatment will almost certainly prove less beneficial to trees than tillage.

5th. *Economic conditions may decide the choice between tillage and some mulching treatment.*— The cost of caring for a sodded orchard is materially less, under this mode of mulching at least, than by tillage. If, then, a man chooses to grow apples extensively rather than intensively he may make larger acreage in sod counterbalance greater production under tillage thereby bringing the cost of production to the same level.

THE LESSON OF THE HITCHINGS ORCHARD.

We end as we began, by saying the Hitchings orchard is unique. The chief lesson it teaches is that a man may break away from the common practice, when circumstances render such practices difficult or impossible, and yet attain a high degree of success. The method of orcharding which takes its name from the Hitchings orchard is not as valuable to the fruit-growers of New York as is the demonstration by Mr. Hitchings that new paths to success may be blazed — new practices devised to meet new conditions, old obstacles overcome in new ways. It is a splendid and successful example of resourceful pioneering and of persistent endeavor to attain the highest success. The pith and the point of the work in this orchard, so different from other orchards in the State, is that fruit-growing is intensely individual. The prime factor is the man.

But from the success of Mr. Hitchings the apple-grower must not be led away from the general truth, that the individual problem can be solved most often by the rational application of the laws of nutrition and growth which plants generally follow. Applied to the problem of growing apples in New York, the general law is, that the apple, like other orchard, field and garden plants, responds to cultivation.

A COMPARISON OF TILLAGE AND SOD MULCH IN AN APPLE ORCHARD.*

SECOND REPORT FOR AUCHTER ORCHARD.

U. P. HEDRICK.

SUMMARY.

This is the third account of studies by the New York Agricultural Experiment Station to determine whether the apple thrives better under tillage or in sod. The first account was published in Bulletin No. 314, 1909; the second in Bulletin No. 375, 1914.

The experiment of which this Bulletin is a report was begun in 1903 in the orchard of Mr. W. D. Auchter, near Rochester, New York. In this orchard are nine and one-half acres of Baldwin trees, 40 feet apart each way, set in 1877. Of these, 118 are in sod, 121 under tillage.

The Auchter orchard was chosen for this experiment because it was uniform in soil and topography and quite typical of the apple lands of western New York. The land is slightly rolling and is a fertile Dunkirk loam, about ten inches in depth, underlaid by a sandy subsoil.

The tilled land was plowed each spring and cultivated from four to seven times. The grass in the sod plat was usually cut once, sometimes twice. In all other operations the care was identical.

The experiment is divided into two five-year periods. During the first period the orchard was divided in halves by a north and south line, during the second period by an east and west line. One-quarter of the orchard, then, has been tilled ten years; another tilled five years and then left in sod five years; the third quarter has been in sod ten years and the fourth quarter in sod five years, then tilled five years.

The following is a statement of results:

The average yield on the plat left in sod for ten years was 69.16 barrels per acre; on the plat tilled ten years, 116.8; difference in favor of tilled plats, 47.64 barrels per acre per year.

The fruit from the sod-mulch plats is more highly colored than that from the tilled land. The sodded fruit matures from one to three weeks earlier than the tilled fruit.

* Reprint of Bulletin No. 383, April; for Popular Edition see p. 933.

The tilled fruit keeps from two to four weeks longer than the sodded fruit; it is also better in quality, being crisper, juicier and of better flavor.

The average gain in diameter of the trunks for the trees in sod for the ten years was 2.39 inches; for the trees under tillage 3.90 inches; gain in favor of tillage 1.51 inches.

The trees in sod lacked uniformity in every organ and function of which note could be taken. The uniformity of the trees under tillage in all particulars was in striking contrast.

The grass had a decided effect on the wood of the trees, there being many more dead branches on the sodded trees and the new wood was not as plump or as bright in color.

The leaves of the tilled trees came out three or four days earlier and remained on the trees several days longer than on the sodded trees. They were a darker, richer green, indicating greater vigor, were larger and more numerous on the tilled trees.

The average cost per acre of growing and harvesting apples in sod was $51.73; under tillage $83.48; difference in favor of sod $31.75. Subtracting these figures from the gross return leaves a " balance " per acre for the sodded plats of $74.31; for the tilled plats, of $140.67, an increase in favor of tillage of $66.36. For every dollar taken from the sodded trees, after deducting growing and harvesting expenses, the tilled trees gave one dollar eighty-nine cents.

The effects of the change from sod to tillage were almost instantaneous. Tree and foliage were favorably affected before midsummer of the first year; and the crop, while below the normal, consisted of apples as large in size as any in the orchard, the falling off in yield being due to poor setting.

The change for the worse was quite as remarkable and as immediate in the quarter of the orchard turned from tillage into sod; the average yield in this quarter was not half that of any one of the other three quarters.

The use of nitrate of soda in the sod plats greatly increased the vigor of the trees and was a paying investment, yet for the five-years period they bore but a trifle more than half as much as the tilled trees.

The very marked beneficial influence on the sodded trees of ground adjacent under tillage teaches that not only should apples not be grown in sod but that for the best good of the trees there should be no sod near them.

Plate XLVII.— Type and Size of Apples on Tilled Soil.

Only in the amount of humus and nitrogen has the soil been appreciably changed by the two treatments. The quantities of humus and nitrogen in the plat tilled ten years are so much greater that it is safe to assume that the tillage and cover-crop treatment conserves humus and nitrogen better than the sod-mulch treatment.

Grass militates against apples growing in sod in several ways which act together, as:

(1) Lowering the water supply,

(2) Decreasing some elements in the food supply,

(3) Reducing the amount of humus,

(4) Lowering the temperature of the soil,

(5) Diminishing the supply of air,

(6) Affecting deleteriously the beneficial micro-flora,

(7) Forming a toxic compound that affects the trees.

General statements are:

Sod is less harmful in deep than in shallow soils.

There is nothing in this experiment to show that apples ever become adapted to grass.

Sod may occasionally be used in making more fruitful an orchard growing too luxuriantly.

Other fruits than the apple are probably harmed quite as much or more by sod.

The effects of grass occur regardless of variety, age of tree, or cultural treatment, and are felt whether the trees are on dwarf or standard stocks.

Because of their shallow root systems, dwarf trees are even more liable to injury from grass than standards.

Hogs, sheep or cattle pastured on sodded orchards do not overcome the bad effects of the grass.

Owners of sodded orchards often do not discover the evil effects of the grass because they have no tilled trees with which to make comparisons.

It is only under highest tillage that apple trees succeed in nurseries and all the evidence shows that they do not behave differently when transplanted.

Grass left as a mulch in an orchard is bad enough. Grass without the mulch is all but fatal — it makes the trees sterile and paralyzes their growth. It is the chief cause of unprofitable orchards in New York.

INTRODUCTION.

A few years ago it was thought that some method of growing apples in sod might take the place of cultivation in the orchards of New York. The Hitchings method of cutting the grass and letting it lie as a mulch seemed to meet the conditions in this State better than any other of the sod or mulch systems and in response to a popular demand this Station began a comparative test of tillage and the Hitchings sod-mulch method in two orchards. The two tests were begun in 1903, and in 1909 a preliminary report was made in Bulletin No. 314 of one of the experiments, that in the Auchter orchard near Rochester, and in Bulletin No. 375, published in March, 1914, a complete report was made of the other test which was carried on in the Hitchings orchard near Syracuse. This is, therefore, the third account of these orchard-management experiments and is given to complete the preliminary report of 1909 of the work in the Auchter orchard.

THE AUCHTER ORCHARD EXPERIMENTS.

LOCATION.

The orchard in which the experiment under discussion was carried on is located on the farm of W. D. Auchter, Elmgrove, New York, seven miles west of Rochester. The site is in the center of the great apple belt of western New York. The orchard was selected because it was the most typical one to be found in topography, soil, variety of apples and in condition at the beginning of the experiment.

The land lies in a rolling plain, one of the ridges of which begins at about the center of the west end of the orchard and runs diagonally lengthwise towards the southeast corner. From this low and somewhat stony ridge the land falls gently away both north and south. About an acre in the southwest corner of the orchard is more depressed than the rest of the field, dropping at the lowest point fifteen feet from the summit of the ridge. This lowland is tile drained but artificial drainage for the rest of the orchard is not needed.

SOIL.

Though the orchard was chosen because variations in the land were few and not great, yet the character of the surface soil changes slightly with the lay of the land. On the ridge and its slopes the surface soil is a sandy loam of the Dunkirk series, nine or ten inches deep and underlaid by a compact sandy subsoil. In the acre depression the type changes to a dark colored Dunkirk loam, ten to twelve inches deep, also underlaid by a fine compact sand. The subsoil grows coarser as the depth increases providing very good natural drainage. Table I shows the composition of the soil and subsoil as determined by mechanical analysis. Table II gives the necessary data as to the chemical constituents of the soil.

TABLE I.— MECHANICAL COMPOSITION OF THE SOILS AND SUBSOILS IN THE AUCHTER ORCHARD.

DESCRIPTION.	Coarse sand, 1—0.5 mm.	Medium sand, 0.5—0.25 mm.	Fine sand, 0.25—0.1 mm.	Very fine sand, 0.1—0.05 mm.	Silt, 0.05—0.005 mm.	Clay, below 0.005 mm.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Dunkirk sandy loam, 0—9 inches......	11.7	52.3	3.6	11.1	15.5	5.6
Subsoil............	9.0	60.5	7.1	9.7	8.4	5.1
Dunkirk loam, 0—11 inches...........	4.4	26.2	9.7	30.0	19.1	10.6
Subsoil............	.3	15.6	21.5	27.9	29.0	5.5

TABLE II.— CHEMICAL COMPOSITION OF SOIL SAMPLES FROM AUCHTER ORCHARD.

LOCATION.	POUNDS PER ACRE IN FIRST SEVEN INCHES.											
	P_2O_5.	P.	CaO.	Ca.	MgO.	Mg.	K_2O.	K.	$CaCO_3$.	CO_2	Total carbon.	N.
Plat 1.....	2,380	1,040	17,400	12,400	13,000	7,800	36,800	30,600	1,340	600	29,400	2,600
Plat 2.....	3,080	1,340	14,400	10,200	11,600	7,000	36,200	26,560	1,440	640	41,800	3,400
Plat 3.....	2,200	960	13,400	9,600	7,000	4,200	35,000	29,800	1,160	520	30,400	2,400
Plat 4.....	2,940	1,280	16,400	11,800	10,400	6,200	34,800	28,800	1,100	540	30,800	2,800
Plat 5.....	2,660	1,160	13,000	9,200	7,400	4,400	35,200	29,200	960	440	42,800	3,400
Plat 6.....	2,800	1,220	14,600	10,400	8,600	5,200	35,200	29,200	1,600	720	35,000	3,200
Plat 7.....	2,940	1,280	14,000	10,000	8,600	5,200	32,800	27,200	1,500	680	45,000	3,600
Plat 8.....	2,940	1,280	15,000	10,600	10,200	6,200	23,800	19,800	2,160	960	37,200	3,000

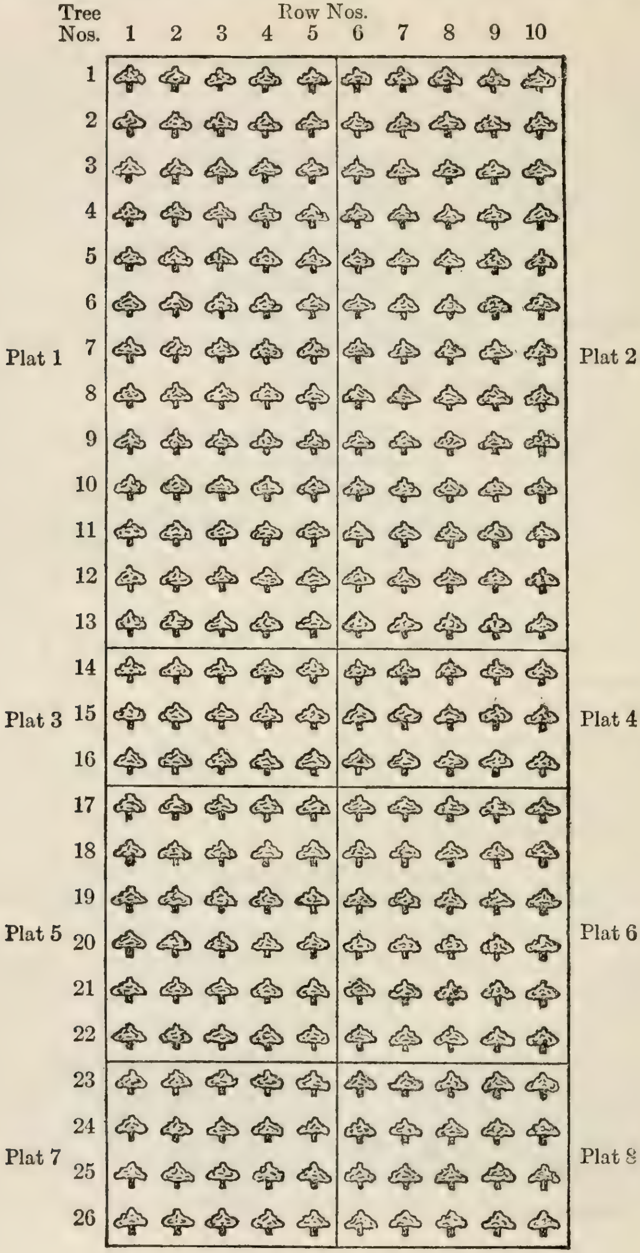

DIAGRAM 4.—PLAN OF AUCHTER ORCHARD.
See opposite page.

PLATS.

The Auchter orchard consists of a little over nine and one-half acres of Baldwin trees set in 1877 at a distance apart of 40 feet. There are ten rows in the orchard, each having 26 trees. During the first twenty years of its existence the orchard was badly neglected, the results of which are shown in several derelict trees which, with a few replaced trees, are not in the experiment. For several years before the land was leased by the Station, the orchard had been under tillage with an annual cover-crop and had borne very good crops. Diagram 4 is a chart of the orchard showing the plats, which may be further described as follows:

Plat 1 was in sod the first five years; cultivated the last five years.

Plat 2 has been cultivated for ten years.

Plat 3 has been in sod ten years.

Plat 4 was cultivated five years; in sod during the past five years.

Plat 5 has been in sod ten years with applications of nitrate of soda the past five years.

Plat 6 was cultivated the first five years; in sod the last five years with applications of nitrate of soda.

Plat 7 has been in sod ten years.

Plat 8 was cultivated five years and has been in sod during the past five years.

MANAGEMENT OF PLATS.

The trees in all of the plats have received as nearly identical care as possible in all operations excepting soil treatment. The soil in the sod area and the tilled area has been managed as follows:

Sod plat.— Since one half of the area which was to be under sod during this experiment had been under cultivation the previous five years, it was necessary to seed down this part in 1909. The ground was fitted in the spring and on June 2 a mixture of blue grass, orchard grass, timothy and clover seed was sowed. The half of the area which was in sod at the beginning of the experiment was cut June 3 and August 3. Throughout the experiment the grass was left where it fell, none being removed from the orchard. The dates of mowing for the five years were as follows:

1909 — June 3 and August 3; 1910 — June 6; 1911 — May 30 and July 27; 1912 — June 7; 1913 — May and July 26.

Tilled plat.— The following is the record of the treatment of the tilled area:

1909.— Plat plowed April 11–13; rolled and dragged April 16; harrowed May 27–28, June 9, June 25, July 9, July 21. On July 28 clover was sown and covered with a weeder.

1910.— Plowed and fitted May 27–31; harrowed June 17–18, July 2, July 12, July 25. Clover was sown July 28 and covered with a weeder. The following day it was rolled down.

1911.— Plowed and fitted April 30–31; harrowed June 1, June 16, June 26, July 4, July 12, July 21–24. Mammoth clover seed was sown on July 24 and dragged in.

1912.— Plowed May 18; harrowed June 11, June 25, July 4, July 13, July 23. A cover-crop of " medium " red clover was sown and dragged in July 25.

1913.— Plowed and harrowed May 5–9; harrowed May 21–24, June 11, July 11, July 25. On July 26 oats were sown as a cover-crop and dragged in.

FERTILIZERS.

Applications of fertilizers were quite incidental to the main purpose of this experiment but their use turned out to be an episode of considerable importance. Fruit-growers who have followed the fertilizer experiments in New York will remember that in this State there is little direct evidence to show that trees profit from potassium or phosphorus applied as commercial fertilizers. In fact, in the orchards of this Station fertilizers containing these two elements were thrown away in one experiment with old trees for twelve years[1] and in another for fifteen years[2] with young trees. The plants gave no adequate response in the first case and none at all in the second. The results in the Auchter orchard tally closely with those at the Station as the following statements show:

When the experiment was in its infancy it was thought that all apple orchards in New York needed phosphorus, accordingly acid phosphate was prescribed and applied to the whole orchard at the rate of 400 pounds per acre. There seems to have been more doubt about the need of potassium; for this element in muriate of potash at the rate of 400 pounds per acre was used experimentally on but two cross-rows, 8 and 9 in the chart, running through both the

[1] N. Y. Sta. Bul. 289: 1907. [2] N. Y. Sta. Bul. 339: 1911.

tilled and the sodded plats. In the light of present knowledge and practice, the quantities used are excessive and the trees should have shown results if this land needed phosphorus or potassium. These superabundant applications were made for three years without visible results.

The fourth season, 1907, the use of acid phosphate for the whole orchard was discontinued but it was applied to cross-rows 12 and 13 at the rate of 15 pounds per tree. The muriate of potash was again applied on rows 8 and 9 and on rows 16 and 17. Negative results followed:— neither in 1907 nor thereafter was there evidence that the trees had been "fertilized." It may be said that nitrogen was the limiting factor and that without it the potassium and phosphorus were inert. But there seemed to be no lack of nitrogen in the tilled plat; rich green foliage, ample annual growth, fruitful trees and large apples, all betokened an abundance of nitrogen presumably supplied by the luxuriant growths of the clover cover-crops plowed under in four of the five years.

In 1910 the whole orchard received an application of quicklime at the rate of one ton per acre. At that time the opinion was current that land for most of our cultivated crops needed lime. It was assumed that the apple could not be hurt and might be benefited, and, not wishing to complicate the experiment with more plats, the whole orchard was limed. There being no checks, the effects cannot be told; but the men in watchful charge of the orchard feel that the use of lime was wholly destitute of definite indications of benefits — no response whatsoever came from the trees.

Beginning five years ago, nitrate of soda has been applied in certain plats in sod as heretofore mentioned. The results were rather remarkable but these are most properly discussed later.

MEASURING THE EFFECTS OF THE TWO TREATMENTS.

Trees probably respond in all characters to cultural treatment, and in like degree. Thus, in the first five years of this experiment,[1] differences were found in fruitfulness, in size, color, maturity and quality of fruit, in diameter of trunk, color of foliage, size and weight of leaves, leafing-time, fall of leaves, annual growth of branches, color and size of new wood, amount of dead wood, depth of roots and spread of roots. In all of these characters the differences are

[1] N. Y. Sta. Bul. 314.

in accord, showing, one and all, that the welfare of the orchard is best served by tillage. With this concurrent response of characters established in the first period of the experiment, it did not seem necessary to use all of the criteria in showing the effects of the two treatments on the orchard during the last period. The ultimate criterion of a method of management is, of course, crop performance. The yield of fruit, then, has been chosen as the chief measure of merit of the two methods in this report. So, too, diameter of trunk is the best standard to measure tree performance and is given as the chief gage of the growth and vigor of the trees.

YIELD OF FRUIT.

The Baldwin is usually a biennial bearer but now and then the trees bear two years in succession and it is seldom that all of the trees in an orchard take the same year off. In the Auchter orchard we have been fortunate enough to have ten crops in succession, the yields being given in Table III. In calculating the value of a crop

TABLE III.— YIELD OF FRUIT ON SOD AND TILLAGE PLATS IN THE AUCHTER ORCHARD.

Year.	Sod Plats.				Tillage Plats.				Gain of tillage over sod in:	
	No. trees.	Barreled apples.	Culls and drops.	Total yield.	No. trees.	Barreled apples.	Culls and drops.	Total yield.	Barreled apples.	Total yield.
		Bbls.	*Bbls.*	*Bbls.*		*Bbls.*	*Bbls.*	*Bbls.*	*Bbls.*	*Bbls.*
1904.......	118	329	286.1	615.1	121	316	275.9	591.9	—13	—23.2
1905.......	118	161.3	71.7	233	121	183.3	95.6	278.9	22	45.9
1906.......	118	167.3	43	210.3	121	345.3	185.8	531.1	178	320.8
1907.......	118	188.3	87	275.3	121	311.3	113	424.3	123	149
1908.......	118	272.8	52.5	325.3	121	540.8	181.7	722.5	268	397.2
1909.......	118	84	91	175	121	307	211.7	518.7	223	343.7
1910.......	118	180	122.3	302.3	120	248	89.3	337.3	68	35
1911.......	118	28	26.3	54.3	119	441	283.1	724.1	413	669.8
1912.......	118	523	141.3	664.3	119	499	219.3	718.3	—24	54
1913.......	118	349	81.4	430.4	119	570	131.2	701.2	221	270.8
Average....	......	228.3	100.3	328.5	......	376.2	178.8	554.8	147.9	226.3
Acre average	......	48.06	21.11	69.16	......	79.2	37.62	116.8	31.14	47.64
Tree average	......	1.766	.776	2.542	......	2.91	1.38	4.29	1.14	1.75

of apples we must, of course, know the quantities of the barrelled stock and culls. These data are given in the table presented. But the figures for total yield are by far the most important in comparing the results of the two treatments in this orchard; for, while grading assorts apples somewhat in accordance with size, yet the quantities of seconds and culls are always more or less increased by fruits

made imperfect by insects, fungi or other injuries. Attention, then, is especially directed to the columns of total yields and still more especially to the column showing the difference between the total yields of the sodded and tilled plats.

Taking, then, the differences in total yield as the best measure of the two methods of treatment, we have no difficulty in coming to a conclusion as to whether sod or tillage is better for the apple. A summary of the figures speaks eloquently for tillage. Thus, during the ten years of this experiment the tilled trees have produced nearly twice as much fruit as those in sod; the bearing capacity of the tilled trees the last five years was greater by 450 barrels than the first five, whereas during the second five years the sodded trees bore 33 barrels less than in the first period — showing that apple trees in sod cannot hold their own but fall behind. Sod is not only less beneficial than tillage but it is positively harmful.

The showing for tillage, of course, would have been still better had not Plats 5 and 6 in the sodded section received applications of nitrate of soda which increased the yield, as shown in Table VI.

SIZE, COLOR, MATURITY AND QUALITY OF FRUIT.

Size.— The size of Baldwin apples is important only as it has a bearing on the yield, for the fruits of this variety are large enough, as grown either in sod or under tillage, to be acceptable in the markets. But the yield in fruit, of course, is greatly increased by increase in size, and thus this character becomes important.

Data taken in the first five-year period, published in Bulletin No. 314 (page 97) show that the tilled apples are nearly one-third larger than those grown under sod — a very telling advantage in crop production. Size alone considered, if the 5–7 ratio of bigness holds for the whole crop, the proportion of culls and seconds is much larger in the sodded than in the tilled plat. Since the yield of the tilled trees is nearly double that of those in sod the number of fruits must be greater on tilled than on sodded trees. To those who have been in the orchard in harvest time, however, figures are unnecessary to show that tillage gives more and larger apples — in no other way is the tale of the deleteriousness of the sod told so strikingly as to the eye at picking time when the size and number of fruits are compared. Plate XLVII shows the type and gives an idea of the size of the apples grown under tillage.

Color.— In America, fashion calls for red apples. The apples grown in sod in this experiment, as is the case in all sodded orchards in New York, comply with the fashion and are brilliantly colored, while those grown under tillage are of sombre hues. This is the single instance in which sod-mulched fruit surpasses tilled fruit. But as we have pointed out in the two previous bulletins from this Station having to do with apples under these two methods of treatment, abnormally bright color indicates constitutional disease or decrepitude. The coloring matter in the skins of apples is modified chlorophyll and as the chlorophyll of leaves becomes brilliantly colored in autumn tints, preceding maturity and decay, so the bright red of the sod-grown apple may be regarded as premature ripening preliminary to decay; for the sodded apples, as we shall see in the next division of our subject, mature and pass out of season more quickly than the tilled apples.

The fact that sod-grown apples are always the most highly colored fruits, disproves the current opinion that the color of apples is almost wholly a matter of climate. The statement is found everywhere in pomological literature that sunlight produces brilliant colors in fruit — that, like the complexion of Shakespeare's dusky Moor, the red color of apples "is but the burnished rays of the burning sun." Rather, we shall find, as in this experiment, that high color is more a matter of maturity than of climate, maturity, of course, often, but not always, being dependent on climate.

Maturity and keeping-quality of apples.— In all of the ten years of this experiment the sod-mulched fruit has ripened materially earlier and has been picked from one to three weeks sooner than that under tillage, depending upon the weather. Thus, if the season was wet and cool the difference in ripening time was but a few days but if dry and warm it ranged from one to three weeks. This is an intensification of the deleterious action of the sod and affects the product in three ways; it causes smaller fruit, a shorter season of usefulness in common storage, and poorer quality.

The difference in keeping quality was usually more marked in common storage than that of time of maturity. In cold storage, tests carried on by the United States Department of Agriculture during the first five years, as reported in Bulletin No. 314 [1] from this

[1] N. Y. Sta. Bul. 314: pp. 99–101. 1909.

Station, showed but little difference, fruit under both treatments keeping equally well until the end of the commercial storage season.

Quality of the fruit.— What is quality? The word is rolled under the tongue by both fruit-growers and consumers as meaning much, but like " good cheer " in the fable is " fish to one, flesh to another, and fowl to a third." As the word is here used, quality is, in brief, that combination of flavor, aroma, juiciness and tender flesh which makes fruits agreeable to the palate. Quality has, and is coming more and more to have, commercial value and the effects, therefore, of the two treatments on apples in this respect are most important.

The tilled fruit in this orchard is much better in quality than that from the sod-mulch plats, a fact affirmed every year by those who have to do with the experiment and attested by all fruit-growers who have eaten the apples with a comparison in mind. Let us take the evidence of Mr. G. Harold Powell, of the United States Department of Agriculture, as one of the witnesses. In this report on the keeping qualities of this fruit, noted in the second paragraph before this, he says:

(March 1st, 1907.) " The texture of the sod fruit was coarse and the flavor was insipid, with a trace of bitterness in it. The tillage apples were brittle and semi-firm in texture, aromatic and good in flavor."

(End of the commercial storage season, 1908.) " There was a distinct difference in quality in favor of the apples from the cultivated land, the fruit from the sod trees, though finer in color, having a coarse texture and an insipid, slightly bitter flavor."

" At the time this report is made, February 8, 1909, there is considerable Baldwin spot in the different lots of fruit and the apples from the cultivated trees though of poorer color were finer in quality than the fruit from the sod trees."

As to the findings at the Geneva Station we cannot do better than to quote a part of the preliminary report on quality in Bulletin No. 314[1] from this Station:

" The difference in quality is due chiefly to a difference in the texture of the flesh. In eating, the tissues of the tilled fruit are turgid and crisp while in the apples from the sod-mulch plat there is a tendency to dryness and mealiness. A determination of the water content, however, does not show much difference in this

[1] N. Y. Sta. Bul. 314: 101, 102. 1909.

respect, the tilled fruit having 84.37 per ct. moisture, the sod-mulch fruit 84.17 per ct. There is no appreciable difference in the specific gravity of the most of the fruit from the two plats as indicated by the hydrometer, showing that the percentage of soluble solids is practically the same in the two products."

"There are noteworthy differences in the flesh of the two fruits. That of the apples from the sodded trees is yellowish in color and frequently tinted with red at the circumference while that of the apples from the tilled trees is greenish and never tinted. Of more importance commercially is the fact that the flesh of the sodded fruit is more frequently spotted with the "Baldwin spot," a dry, corky condition of portions of the flesh due probably to some physiological trouble. This corky tissue sometimes envelops the core and in other specimens involves not a little of the circumference of the fruit. Such a physiological defect must be considered as a result of some harmful disturbance in the well-being of the tree."

EFFECTS OF THE TWO TREATMENTS ON THE TREES.

Diameter of trunks.— Experience with several orchard experiments shows plainly that if but one phase of growth is chosen to measure health and vigor of tree, increase in diameter of trunk is much the most satisfactory. Increase in growth and vigor of the whole tree is directly proportional to the increase in the diameter of the trunks. Table IV shows the gains in diameter of the trunks of the trees tilled ten years over those in sod ten years. The diameters are those of mid-trunk, the lengths of these trunks averaging about four and one-half feet. The final figures show most strikingly the greater growth of the tilled trees. We begin to realize the magnitude of

TABLE IV.— GAIN IN TRUNK DIAMETERS OF TREES TEN YEARS IN SOD AND TEN YEARS UNDER TILLAGE.

YEAR.	SOD-AVERAGE OF 61 TREES.					TILLAGE-AVERAGE OF 60 TREES.				
	Row 1.	Row 2.	Row 3.	Row 4.	Row 5.	Row 6.	Row 7.	Row 8.	Row 9.	Row 10.
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
1913......	16.30	16.69	16.04	15.92	15.55	16.41	16.62	17.06	17.57	18.12
1904......	13.53	14.38	13.88	13.73	13.01	12.66	12.83	13.19	13.89	13.71
Gain......	2.77	2.31	2.16	2.19	2.54	3.75	3.79	3.87	3.68	4.41

Average gain for sod 2.39 in., average gain for tillage 3.90 in., average gain of tillage over sod, 1.51 in.

the deleterious effect of sod when we add the illuminating evidence, that the trees have grown comparatively little in ten years, to that regarding yields which shows that they were actually bearing less fruit than formerly. The conjunction of the two spells ruin.

Plate XLVIII, though made from a photograph taken at a considerable distance from the orchard, shows that the trees in sod, corresponding to the trunk diameters, are smaller than those under tillage.

Uniformity of trees.— In no respect do the trees in sod in this orchard show injury more strikingly than in the matter of uniformity. They lacked uniformity in every organ and function of which note could be taken. To particularize: A tree in sod would bear on one branch, not on others; fruit on one side would be large, on another small; or, the crop would be well-colored in part and the remainder poorly colored; branches and foliage differed much on individual trees; the circumference of the root system of the sodded trees was very irregular in outline and uneven in depth. The lack of uniformity was, of course, much more noticeable in the respects named in distinct trees in sod, even though growing side by side, than in branches of individual trees. Intermittency in bearing of all trees in sod was greater than under tillage.

On the contrary, one of the most illuminating pieces of evidence favoring cultivation for this or any other crop was the uniformity of the trees in tillage — a condition the desirability of which is so obvious as to need no discussion.

The reason for this difference in uniformity, set forth at greater length in the previous report on this orchard, is the lack of uniformity in the environment of the sodded trees and the greater uniformity brought about by tillage,— as, surface uniformity, equal depths of soil, and evenness in the amount and availability of air, food, moisture and temperature.

Color and condition of wood.— There is an extraordinary effect of the grass on the color of the new wood, which was mentioned in the previous report and, while it may be of minor importance to the trees, is well worth again noting, since the phenomenon has intensified as the experiment progressed. The differences in the wood can best be described in the words of the first description.[1]

" The whole tree top on the tilled land is a light, bright, glossy olive-green color, emphasized somewhat by the plumpness of the

[1] N. Y. Sta. Bul. 314: 108. 1909.

twigs and the tautness of the bark. The tree tops on the sod-mulch plat were darker, of a brownish cast and less glossy and bright, giving a prevailing color that distinguished the sod-mulch plat from the tilled plat a mile away."

Any one with experience would pick the tilled trees as the healthier from the condition of the new wood.

As the experiment has progressed the dead wood in the sodded trees, noted in the first report, has increased out of all proportion to expectations from the first few years' work. This dead wood, in the quantities present, was so certain a sign of failing vigor and decrepitude that the owner at the close of the ten-year period feared for the life of his trees if they were to be kept in sod. The decrepit and moribund condition of sodded orchards in New York, even when mulched, as indicated by dead wood, has done much to drive sod mulching out of practice in commercial orchards in this State.

FOLIAGE.

The importance of good foliage.— In the most literal sense " light is life " for plants. Foliage absorbs energy from the sun's rays and, as every school-boy knows, plants have a marvelous faculty of developing and placing their leaves so that the largest possible amount of sunlight will be absorbed. Under the influence of the sun's rays the carbonic acid of the air and the soil solution are synthesized into the organic materials from which the plant tissues are constructed. The foliage, then, is the assimilating apparatus of the apple-tree. In a slightly different sense it may be said to be the breathing apparatus of the tree. Or, in another way a leaf is well called a solar engine getting its energy from the light rather than from the heat of the sun. In any and all of these aspects of the functions of foliage it is seen at once that the efficiency of an apple-tree depends in large measure upon its foliage. What is the effect of these two methods of treatment upon the foliage of the trees in this experiment?

Color of foliage.— The part of the leaf which acquires energy from light is the chlorophyll, the green coloring matter, found in the leaves of all higher plants. Now the amount of this indispensable chlorophyll in the leaf of an apple is measured by the depth and richness of the green of the foliage. Leaf-color is the readiest and most delicate gage the fruit-grower can use in determining the well-

TILLAGE. | SOD MULCH.

PLATE XLVIII.—RELATIVE SIZE OF TREES UNDER TILLAGE AND IN SOD MULCH.

PLATE XLIX.—TREE ON TILLED PLAT SHOWING CHARACTER OF FOLIAGE.

Plate L.— Tree on Sod-mulch Plat Showing Character of Foliage.

Plate LI.— Roots Entering Tilled Plat from Sod.
Twenty Feet from Tree.

Plate LII.— Roots Thirty to Forty Feet Long Passing Under Stone Wall between Sod Plat and Lane.

being of his trees even though reliance must be placed on the eye alone to secure evidence. Judged by color of foliage there was, in any year, no time while the leaves were out that even the novice in fruit-growing would not have declared the tilled trees the more vigorous and healthy. The pale, sickly color of the sodded trees could be distinguished from the rich green of those under tillage fully a half mile away as one approached the experimental plats.

The appearance of the foliage of sodded trees is so characteristic that we venture the assertion that we can recognize a sod-bound apple-tree from its unthrifty foliage, mulch or no mulch, find it where you may in western New York, at any time from June to October. In passing, it must be said that, everywhere in New York, in driving by orchards the tell-tale tints of the leaves speak convincingly of the better health and greater vigor of tilled apple-trees to those who have eyes to see.

Number and size of leaves.— The number and size of the leaves tell the same tale of some kind of interference in the protoplasmic activity in the leaves on the sodded tree. It required but a glance to satisfy oneself that the leaves on the tilled trees were larger and more numerous, and therefore total leaf area much greater on the tilled than on the sodded trees. Undoubtedly the number and the size of the leaves shut out the sunlight somewhat from the fruit and thus help to account for its later maturity and poorer coloring on the tilled trees. Plates XLIX and L give some idea of the relative size and denseness of the leaves in the two plats.

In the first report on this experiment an attempt was made to measure roughly the relative efficiency of the foliage of the trees under the two treatments by weighing leaves.[1] It was found, in short, that the leaves of the tilled trees weigh one and one-third times as much as those of the sodded trees indicating one and one-third greater efficiency of the foliage of the tilled trees.

Leafing-time and fall of leaf.— Not only were the leaves on the tilled trees more efficient in furnishing food for the trees because of more chlorophyll and greater size and larger numbers but they remained on the trees longer at both ends of the season and thus contributed to superior vigor and health. The leaves of the tilled trees came out from two to five days earlier in the Auchter orchard and remained on from a week to two weeks longer. In the northern

[1] N. Y. Sta. Bul. 314: 105. 1909.

climate of New York this curtailment of the season for the sodded trees must have lessened growth of tree considerably and hastened maturity of fruit not a little. In these life events the trees in the Auchter and the Hitchings [2] orchards behaved alike.

FINANCIAL STATEMENT.

After all it is the pecuniary rewards that mean most for a method of farm management. The method that makes fruit-growing most profitable is best. It is safe to use financial data in fruit-growing only provided they be taken over a sufficiently long time to offset

TABLE V.— EXPENSES OF CULTURE AND HARVESTING AND BALANCE IN AUCHTER ORCHARD FOR TEN YEARS.

SOD PLAT — 118 TREES.

YEAR.	Fertilizer.	Pruning.	Cutting grass.	Spraying.	Harvesting (inc. bbls.).	Total.	Balance.
1904	$15.05	$14.62	$19.99	$58.22	$219.25	$327.13	$225.76
1905	18.60	13.25	7.46	44.27	82.89	166.47	330.28
1906	17.00	15.12	3.36	46.51	104.30	186.29	154.96
1907	8.37	15.33	3.67	73.84	138.07	239.28	487.16
1908	....	16.86	6.14	50.45	173.43	246.88	353.86
1909	....	16.69	7.65	61.75	84.60	170.69	136.99
1910	....	13.62	9.10	49.70	164.38	236.80	481.61
1911	....	14.25	9.10	51.97	27.96	103.28	—19.13
1912	....	19.50	5.00	52.84	383.54	460.88	670.93
1913	....	21.87	7.50	46.35	243.86	319.58	707.48
Total	$59.02	$161.11	$78.97	$535.90	$1,622.28	$2,457.28	$3,529.90
Per acre per year	1.24	3.39	1.66	11.28	34.15	51.73	74.31
Per barrel	.018	.049	.024	.167	.493	.748	....

TILLED PLAT — 120 TREES.

YEAR.	Fertilizer.	Pruning.	Cultivation.	Spraying.	Harvesting (inc. bbls.).	Total.	Balance.
1904	$15.05	$14.62	$33.75	$58.22	$210.90	$332.55	$185.34
1905	18.60	13.25	48.71	44.27	96.85	221.68	355.60
1906	17.00	15.12	30.30	46.51	231.80	340.73	392.42
1907	8.37	18.31	46.63	73.84	224.20	371.35	800.31
1908	....	22.10	36.67	50.45	338.59	447.81	723.41
1909	....	16.69	60.85	61.75	229.91	369.20	894.20
1910	....	13.62	55.15	49.70	183.89	302.36	625.20
1911	....	14.25	61.91	51.97	373.20	501.33	816.52
1912	....	19.50	56.89	52.84	415.51	544.74	585.80
1913	....	21.87	50.50	46.35	415.24	533.96	1,303.30
Total	$59.02	$169.33	$481.36	$535.90	$2,720.09	$3,965.71	$6,682.10
Per acre per year	1.24	3.56	10.13	11.28	57.26	83.48	140.67
Per barrel	.01	.03	.087	.097	.49	.715	....

[2] N. Y. Sta. Bul. 375: 73. 1914.

accidental variations. Average figures for ten crops ought to give a fairly safe standard of measurement. Table V gives the figures of expenses and profits,— of which the following is a brief summary.

The average cost per acre of growing and harvesting apples in sod was $51.73, while under tillage the cost was $83.48, the difference in favor of sod being $31.75. Subtracting these figures from the gross income gives an average " balance " per acre for the sodded plats of $74.31 while the " balance " per acre from the tilled plats was $140.67, an increase of $66.36 in favor of tillage. In other words, for every dollar remaining from the sod income, after deducting cost of growing and harvesting, the tilled trees gave a similar balance of one dollar eighty-nine cents. That is to say, since the remaining fixed charges are practically equal for the tilled and sodded areas, tillage gave nearly double the profits in this ten-year period that sod gave.

The income from the tilled half of the Auchter orchard furnished a good basis for calculating the profits of a New York apple orchard. The cost of the various operations, of the materials used, and the selling prices and profits of this orchard for the ten years for which it was leased by the Station, are published in Bulletin No. 376.

MINOR EXPERIMENTS IN THE AUCHTER ORCHARD.

In the test as planned in 1903 the south half of the orchard, five rows of twenty-six trees each, was in sod; the north half under tillage. During the last five years the east half of the orchard has been in sod; the west half under tillage. Certain rows in the sod section of the last period have had annual applications of nitrate of soda while the remaining rows have not been so fertilized. Reference to the diagram on page 254 and to the plan of the plats on page 255 will make clear the redivision of the work made in 1909. We must now briefly discuss these minor experiments.

The change from sod to tillage.— Plat I, consisting of the southwest quarter of the orchard, was in sod the first five and under tillage the second five years. How long did it take the sodded trees to "come back"? The effects were almost instantaneous and soonest discovered and probably best measured by the eye. During the last season of the first period the leaves on the sodded trees were few, small and of a sickly, yellow color. In mid-season of the first summer of tillage in this plat the color was the normal healthy green

of tilled trees but the foliage was still somewhat sparse. The crop of this first season was a little below the normal in amount, the falling off being due to poor setting rather than to small size of apples. The second year the foliage was normal in all respects and the crop was the best per tree of all plats in the experiment as it was again in the third year and the fifth while the fourth season the yield was much above the normal, being exceeded in the tree average only by two other plats.

TABLE VI.—YIELD OF PLATS AND TREE AVERAGES IN AUCHTER ORCHARD IN SECOND-HALF OF TEST.

YEAR.	PLAT 1. 57 TREES.		PLAT 2. 62–60 TREES.		PLAT 3. 15 TREES.		PLAT 4 10 TREES.	
	Total yield.	Yield per tree.	Total yield.	Yield per tree.	Total yield.	Yield per tree.	Total yield.	Yield per tree.
	Bbls.	*Bbls.*	*Bbls.*	*Bbls.*	*Bbls.*	*Bbls.*	*Bbls.*	*Bbls.*
1909	129	2.3	390	6.3	24	1.6	7.3	.73
1910	222.7	4.0	115	1.9	25.7	1.7	13	1.3
1911	478.1	8.4	246.1	4.1	2.7	.17	4.3	.43
1912	250.1	4.4	468.2	7.8	54.7	3.6	34	3.4
1913	393.5	7	307.7	5.1	37	2.5	12.3	1.23
Average per tree	.....	5.17	.....	5.03	.....	1.92	.....	1.41

TABLE VI.—YIELD OF PLATS AND TREE AVERAGES IN AUCHTER ORCHARD IN SECOND-HALF OF TEST—(Concluded).

YEAR.	PLAT 5. 28 TREES.		PLAT 6. 30 TREES.		PLAT 7. 18 TREES.		PLAT 8. 19 TREES.	
	Total yield.	Yield per tree.	Total yield.	Yield per tree.	Total yield.	Yield per tree.	Total yield.	Yield per tree.
	Bbls.	*Bbls.*	*Bbls.*	*Bbls.*	*Bbls.*	*Bbls.*	*Bbls.*	*Bbls.*
1909	83	3.	20	.66	44	2.5	14.3	.75
1910	107	3.9	66.7	2.2	25.7	1.4	64.3	3.4
1911	15.3	.54	21.7	.72	4	.22	6.3	.33
1912	225.7	8.1	170.7	5.7	67.4	3.8	112	5.9
1913	118.4	4.2	90.5	3	104.9	5.8	49.3	2.59
Average per tree	.....	3.90	.....	2.46	.....	2.73	.....	2.59

Table VI gives the yields of the several plats during the last five years of the experiment and shows graphically the change in productiveness with the change from sod to tillage.

Incidentally there is evidence here to show that the quantity of the chief food elements is a minor matter in this experiment. Of the eight plats in the orchard, the one changed from sod to tillage has least humus, as gaged by carbon, and is next to the lowest in nitrogen and phosphorus. Yet without additions of fertilizers in the change from sod to tillage, the plat almost immediately became the most productive in the orchard. It is doubtful if the humus or the available food turned over in the sod wholly accounts for the increased productivity of this plat.

The change from tillage to sod.— Plats 4, 6 and 8, constituting the northeast quarter of the orchard, were cultivated the first half of the ten years and were in sod the last half. The change for the worse was quite as remarkable in this quarter of the orchard as it was for the better in the quarter turned from sod into tillage. The trees began to show the effects of the grass in their foliage before mid-summer of the first season. The deterioration of the trees as a whole began this first season and became increasingly greater from year to year until the end of the experiment. In the quarter of the orchard ten years under tillage the average yield per tree for the last five years was 5.03 barrels per tree; in the quarter five years in sod followed by five years of tillage the average yield per tree was 5.17 barrels for the same period; but in the quarter five years in tillage followed by sod the average yield was but 2.32 barrels per tree for the five years of sod — not half that of either of the other two sections. These figures are modified somewhat to the advantage of sod by the application of nitrate of soda in Plat 6.

In accounting for the all but fatal effects of grass on the trees in this orchard we are almost forced to assign the toxic effect of grass as one of the causes of grass injury. One of the chief evidences that grass has a toxic effect on apples is to be found in the behavior of the trees in this newly sodded area. It does not seem possible that drought, lack of food, lack of air, or any other assignable cause than some toxic property, acting before mid-summer — almost immediately,— could have caused the trees in this plat to have taken on the symptoms of sod-bound trees as soon as the roots of the young grass came in contact with those of the trees.

The use of nitrate of soda in the sod plats.— Potassium, phosphorus and lime were all used liberally in the first half of the ten-year period, as we have seen in the discussion of fertilizers, page 256. Nitrogen

was supplied to the tilled trees during the whole period by plowing under clover cover-crops. It was reasonable to assume that the sodded trees were suffering from a lack of nitrogen in the last half of the experimental decade. Therefore, Plats 5 and 6 in the sodded half of the orchard, containing 52 of the 120 trees in sod, were given annual applications, five in all, of nitrate of soda at the rate of 350 pounds per acre, a heavy dose. In some respects the results were most surprising. The foliage was abundant and of a dark, rich green, nearly as luxuriant as that of the tilled trees. There were, therefore, high hopes of abundant harvests. Table VI, however, shows that, while the trees which were thus fertilized yielded more than those not so treated in sod, they bore on an average but a trifle more than half as much as those under tillage, the figures being 3.17 barrels per tree for those in sod which had nitrogen; 2.28 barrels for sodded trees without the nitrate and 5.03 barrels per tree for the trees cultivated ten years. A little calculation shows that the nitrate of soda paid well for itself.

The question will be asked, why was not the nitrate of soda tried on the tilled land? The answer is, that at all times the tilled trees seemed to be having too much nitrogen judging from leaf and wood growth and the size and color of the fruit. The clover cover-crops supplied more than the trees seemed to need.

Influence on sodded trees of adjacent ground under tillage.— Plats 7 and 8 show very considerably larger yields than Plats 3 and 4 though all had the same treatment. So, too, the diameters of the trees are greater in Plats 7 and 8. Why? Unquestionably, because the roots of the trees in the outside rows in Plats 7 and 8 found their way into adjacent ground under tillage though separated from the cultivated land by a strip of sod 20 feet wide. They have, too, far greater light area. Even the halves of the trees on the outside were superior to the halves on the inside, in yield of fruit and luxuriance of foliage. Account should be taken of this fact in considering the results, for the evil effects of the grass in the sodded plats have been diminished not a little by the escape of some of the roots of sodded trees from the sod to the tilled land which surrounds the orchard. Plates LI and LII, reproduced from Bulletin No. 314, show how roots from the sod pass into tilled land though none were passing the other way.

The facts stated in the last paragraph clearly teach that not only should apple-trees not be grown in sod but that the root-run of the trees should not be restricted by sod on any side of the tree. For the best good of the trees, there should be no sod near the trees. Just as we have shown a most favorable influence on sodded trees from adjacent tilled land, so, too, trees can similarly escape from sod by sending their roots downward if the soil be deep.

EFFECTS OF THE SEVERAL TREATMENTS ON THE SOIL.

What were the effects of the two treatments on the soil? A positive answer would lead straight to the pith of our problem, that of determining the relative merits of two methods of soil treatment. But we cannot be as positive as we should like. Analyses were not made at the beginning of the experiment and in determining the effects of the two treatments on the soil one must rely chiefly on the behavior of the plants and much less on analyses made at the end of the ten years' treatment. The results as measured by plant behavior have been given and we have now to see how these correspond with the condition of the soil as determined by chemical analyses set forth in Table II, page 533.

We may as well dispense with a consideration of the figures for all of the compounds and elements in Table II excepting carbon and nitrogen; since there is an abundance of all, excepting the two named, for an orchard soil for this tree generation at least. Applications of phosphorus, potassium and lime, it will be remembered, were without result in this orchard. The carbon content, however, is important. It is an index of the quantity of humus in the soil and the response that the trees have made to nitrogenous cover-crops and fertilizers indicates that the addition and conservation of nitrogen is important in this soil. Figures are given for the top seven inches of soil only, since analyses made of the second layer of seven inches showed that it was improbable that the treatment has had appreciable effect on lower depths. Let us pass, now, to a consideration of figures for carbon and nitrogen in this upper layer as shown in the following summary:

	Carbon	*Nitrogen*
Plat 1, in sod five and tilled five years	29,400 pounds	2,600 pounds
Plat 2, tilled ten years	41,800 pounds	3,400 pounds
Plats 3, 5 and 7 (average of the three) in sod ten years	39,400 pounds	3,100 pounds
Plats 4, 6 and 8 (average of the three) tilled five and in sod five years	34,300 pounds	3,000 pounds

One cannot draw positive conclusions from these figures. It is safe to assume, however, since the quantities of carbon and nitrogen are so materially larger in the plat tilled ten years than in any other plats in the orchard, that the tillage and cover-crop treatment has conserved humus and nitrogen rather better than any other treatment. In fact, since considerable quantities of nitrogen were added to a part of the trees in sod, thereby increasing the growth of vegetation and adding more nitrogen to the soil than the treated trees have probably taken from it, we are safe in assuming that the tillage and cover-crops of clover are unmistakably more conservative of humus and nitrogen than would the sod-mulch method have been without the application of nitrate of soda.

The lower carbon and nitrogen content of Plat 1 is probably accounted for by the difference in the soil type between this and other parts of the orchard, as explained in the description of the soil — the plat is in a depression which has more surface wash than other parts of the orchard. Yet, bear in mind that this was the most productive plat the last half of the experiment.

Comparison of the analyses of the tilled and the sodded soils proves, we again insist, that the miserable condition of the trees in sod cannot be wholly due, in fact can hardly be largely due, to differences in the food constituents in the two soils. Or, if it be a matter of food, the quantities removed from the soil by the apple are so small that they are not appreciable by our rough methods of sampling and analyzing. At any rate we think the statement is warranted from both the soil analyses and the behavior of the trees in this experiment, and from observation in other orchards, that the intensity of the deleterious action of sod is not much influenced by the richness of the soil.

WHY IS TILLAGE BETTER THAN SOD FOR THE APPLE?

In our first report on the Auchter orchard, Bulletin No. 314, we discussed at length the question, "Why is tillage better than sod for the apple." We were not then satisfied that the conclusions reached answered the question as fully or as accurately as might be wished, yet with five years' more work we have but few additional facts to modify the conclusions of the first report. As we tried to show in the previous report the ways in which grass militates against apples growing in sod are probably several, which act together, as:

(1) Lowering the water supply.
(2) Decreasing some elements in the food supply.
(3) Reducing the amount of humus.
(4) Lowering the temperature of the soil.
(5) Diminishing the supply of air.
(6) Affecting deleteriously the beneficial micro-flora.
(7) Forming toxic compounds that affect the trees.

Each of these supposed causes of injury to the sodded trees in this orchard may be briefly reviewed with such additions and corrections as the five more years of experimental work suggest.

Sod injures apple-trees by lowering the supply of water.— In the preliminary report of this experiment (Bulletin No. 314, pages 115 to 121) the reduction of the supply of water was held to be the main cause of the injury to the trees in sod. The results of 120 moisture determinations in the orchard in 1907–08 gave evidence that there was much less moisture in the sodded land than in the tilled soil; the behavior of the trees in sod seemed to show that they were suffering from thirst; and a consideration of the amount of water used by an apple-tree and of the rainfall of the region made plain that there was seldom a year when trees did not suffer from a shortage of water even if the supply was not interfered with by grass.

It is not necessary to review further the data and reasons given in the first report to show that injury by sod is at least in part a question of water supply. We wish here only to reiterate our belief that the great reduction of the water supply is the chief cause of the extraordinary injury to the sodded trees in this experiment. The results of a similar experiment in the Hitchings orchard, as set forth in Bulletin No. 375 from this Station forced us to the same

conclusion. Observations, too, of orchards in all parts of New York show clearly that apples in sod suffer most in soils in which the water supply is deficient.

Fruit-growers must bear in mind in comparing tillage with sod methods that the trees are not only robbed of water by the grass but that tillage conserves moisture — thus the difference in the results from these sodded and tilled trees is due to a bad effect of sod plus a good effect of tillage. It is, then, if we accept the teachings of this test, not only necessary to keep sod out of an orchard but to practice tillage, which, as all know, protects the soil from the drying action of wind and sun and conserves moisture.

Sod injures apple-trees by decreasing some elements of the food supply.— It is impossible to establish a difference between results due to a deficiency of water and those due to a deficiency of food, for all of the food of the tree derived from the soil is taken up in the form of a solution. Therefore, a tree suffering from want of water of necessity suffers from want of food. We may have, then, and probably do have in this experiment, trees starving in a fertile soil because of a lack of water for the soil solution.

There is nothing to indicate that any of the food elements are lacking for either trees or grass in this orchard excepting, possibly, nitrogen in the sodded part — a matter to be discussed in a later paragraph. Analyses made in 1908 [1] and again in 1913, the results of the latter shown in Table II, show, as we have seen, a soil more than rich enough for the apple — a plant the food requirements for which are comparatively small. The trees, it will be remembered, were in no way improved in sod or under tillage by additions for several years of potassium and phosphorus and one heavy application of lime. The trees in the tilled land at no time gave evidence of thinness of fare — they flourished like the Biblical palm. Even in the sod such trees as could get any considerable portion of their roots in the tilled plats or in adjoining tilled fields, prospered in proportion. The growth of grass was always luxuriant, except in stresses of dry weather, giving further evidence that the land is not impoverished. Moreover, we have demonstrated that in this type of soil, in western New York at least, the starvation point for the apple is much lower than for field or garden crops[2] — the trees thrive where grains or

[1] N. Y. Sta. Bul. 314: 124. 1909.
[2] N. Y. Sta. Bul. 339: 1911.

vegetables require fertilization. From all sides, too, come reports from apple-growers who augment, diminish or alter in various ways manurial treatments of their trees without appreciable results.

It must be borne in mind, however, that if these trees were in need of more food, tillage would make available some of the unavailable reserve food which the chemical analyses of the plat show to be present.

To the statements just made there is a seeming exception in the case of nitrogen. The action of nitrate of soda in reviving the sodded trees is almost instantaneous. Yet analyses show nearly as much nitrogen, on the average, for the sodded plats, as for those that have been tilled; indeed, in some of the sodded plats there is more. Moreover, as soon as the sod is turned under, without the addition of commercial nitrogen, the trees revive, grow vigorously and show no signs of the starvation they endured in grass. This behavior can best be accounted for in one of two ways. Either the grass takes the nitrogen, the cream of the land in this orchard, in which case applications of nitrate of soda would so supplement the natural supply as to give the trees a fairer share and thereby give new life; or the nitrate of soda may counteract a toxic effect of the grass. Of the two explanations we are inclined to the first, although we can offer no explanation as to how the grass can so completely exhaust the supply of nitrogen in the soil for apples and yet in a ten-year period not drain it of the fertility in this element upon which the grass itself retains its pristine vigor.

Lyon and Bizzell[1] have found that grasses have a strongly depressive influence on nitrate formation and suggest that this is a possible cause for the injurious effect of sod in orchards. Doubtless such effects would differ with different grasses and with different soils, thus accounting for the wide variations and seeming anomalies in sod and tillage methods in different localities. Lyon and Bizzell's work opens up a promising field for investigation in the relationships of grass and trees.

Sod has injured the trees in the Auchter orchard by reducing the humus content of the soil.— The statement just made is an assumption, pure and simple, so far as humus itself is concerned. It is extremely doubtful if humus in the quantities shown to be present

[1] T. L. Lyon and J. A. Bizzell, "Some Relations of Certain Higher Plants to the Formation of Nitrates in Soils," Cornell Exp. Sta. Memoir No. 1: 75–91. 1913

in all parts of this orchard is necessary for the apple. Fruit trees thrive in many soils in all parts of America where scarcely a tithe of the humus in either the tilled or sodded part of this orchard exists. The highest yields during the past five years in this orchard were in the plat having least humus. It can not be said that the excess of humus, as humus, in the tilled land of this experiment has made any great difference in either yield of fruit or growth of tree. But one of the postulates of agriculture is that humus increases the water-holding capacity of soils and it is not an assumption to say that in this way the greater amount of humus in the tilled land has been helpful.

The " burning out " of humus is one of the bugaboos that those who keep their orchards in sod see in tillage. Analyses made in 1908[1] and again in 1913 as shown in Table II, give satisfactory proof to those who till, that the reduction of humus in a soil through tillage is an imaginary evil. This statement holds, provided, of course, that a cover-crop is used with the tillage. It is not too much to assume, in the light of this and other experiments, that the difference in the amount of humus in a tilled orchard and a sod-mulched orchard will be about the difference in the quantity of cover-crop turned under in the former and the amount of grass left as a mulch in the latter.

Sod injures apples by lowering the temperature of the soil.— Evaporation is a cooling process. It is to be expected, then, that the greater evaporation through the grass and the compact earth in the sodded land gives a cooler soil. The mulch obtained by cultivation, too, is a protection against evaporation with its cooling effects. Facts follow theory in this case and the expected happens. A series of observations made at depths of 6 and 12 inches in the soil in the summer of 1908[2] shows that the tilled soil in June and July is 1.1 degrees warmer at seven in the morning and 2.3 warmer at six in the even ng than the sodded soil. Observations were not made at night but it is doubtful if the soil temperature of the early morning, at least, would be reversed though we might expect it to be less than that of the evening after a day of sunshine. The reversals of night would probably be more than offset by the higher tem-

[1] N. Y. Sta. Bul. 314: 124. 1909.

[2] For a table showing the temperatures see Bulletin 314: 126. 1909.

peratures in the tilled land at noon. These results agree with those of other experiments and with the conclusions of some of the best authorities on soils.[1]

We have no definite knowledge as to whether the apple prefers a warm or a cool soil but in the comparatively cold soils in which the apple is grown in New York, general considerations lead us to believe that the warmer soil is the better. To give reasons: Heat would cause food substances to dissolve more rapidly; hasten diffusion; aid in soil ventilation; develop stronger osmotic pressure in roots; and help in the formation of nitrates. The augmentation of these several processes would, it is almost certain, accelerate vegetative activity sufficiently to make the higher temperature of the tilled land one of the factors accounting for the more flourishing condition of the trees under tillage.

Sod injures apples by diminishing the supply of air in the soil.— We have no data to prove the contention set forth in the heading of this paragraph but concrete evidence is not necessary. All must agree that air is of vital importance to every part of a plant — to the roots scarcely less than to the tops of trees. Beneficient bacteria depend, if anything, to even a greater extent upon an ever present supply of oxygen. The formation of nitrates requires the addition of oxygen to some one or another of the compounds of nitrogen. Oxidation plays an important part in all of the chemical changes which take place in the soil and is therefore necessary in keeping up fertility.

All will grant the proposition that there is more air in a cultivated than in a sodded soil. Nothing can be more apparent than that, when soil particles are held in a close, compact mass as in uncultivated land, there is comparatively little room for air and that when the particles are separated by stirring the soil fresh air must be drawn in. When the air is renewed by stirring the soil several times during a season there cannot but be a most beneficient effect on the plats growing therein. These considerations need no data to prove them, they are corner-stones in agriculture, and justify us in settling upon a diminished air supply as one of the causes for action against grass in an orchard.

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[1] Woburn 3rd Report: 45. 1903.
Soils. By E. W. Hilgard. New York: 1906, p. 305; The Soil. By F. H. King. New York: 1895, pp. 221–225.

Sod affects deleteriously the beneficial micro-organisms in an orchard soil.— This is another statement which we cannot support with experimental evidence. We are assuming than an abundant humus content, good ventilation, comparatively high temperature, a more uniform supply of moisture, more nitrogen from the cover-crop turned under, all present and cooperating better in a tilled than a sodded soil, give the best environmental conditions for these bacteria. If the assumption is unwarranted, our agricultural teaching of the day is radically at fault. In the light of what we know about soil bacteria, little though it be, it is not unreasonable to suggest that the micro-organisms in tilled land are more helpful to apple-trees than in sod-covered land.

Sod may "poison" the apple-trees.— The fact is well established that all plants have a marked effect on soils. Just how plants affect soils is not so clear. Certain it is, in the case of a sod of whatever plant, much organic matter quite different from that present before the sod, is added. It is not in the least strange, rather it is to be expected, that this mass of new matter will change the chemical and bacteriological properties of a soil, for good or evil for other crops. There is, too, as everyone informed on recent agricultural experimentation knows, considerable evidence to show that plants, grass for instance, may excrete compounds toxic to other plants. Is it not possible that sod may, then, set going some action in a soil detrimental to apples? Literally, may not sod poison the apple?

Pickering[1], at the Woburn Experimental Farm, Ridgemont, England, has been experimenting with apple trees in sod and under tillage since 1894, twenty years. The methods employed in the New York experimental work, both in treatment of plats and in gaging results are very similar and the results obtained are for all practical purposes the same. A good summary of the conclusions at Woburn as to causes is found in the following quotation[2]:

"Direct experiments seem to negative the possibility of explaining the action of grass on apple trees in the various ways which we have discussed above, and lead us to a conclusion, which has

[1] All who are interested from the experimental standpoint in this work should read Pickering's accounts of his work in the First, Second, Third and Fifth Reports of the Woburn Experimental Farm.

[2] Third Report of the Woburn Experimental Fruit Farm, 1903: 47.

also gradually been forced upon us by the appearance itself of the trees throughout the years that they have been under observation, namely, that this action of grass is not merely a question of starvation in any form, nor of any simple modification of the ordinary conditions under which a tree can thrive, but that the grass has some actively malignant effect on the tree, some action on it akin to that of direct poisoning."

Thus, it is seen that Pickering believes that there is but one important factor in the injury of trees in sod; namely, grass "which has some actively malignant effect on the tree, some action on it akin to direct poisoning." But the case against grass as a poisoning agent still rests largely on circumstantial evidence; or, rather, as we understand Pickering's arguments, he arrives at his conclusions as to the toxic effect of grass by eliminating all other possible causes, admitting that he cannot present his supposition as a proved fact "till the presence of such poison is definitely established."

Pickering's work has been so long continued and so carefully carried on that great weight must be attached to his opinion. Yet we cannot agree with him that the malignancy of grass is wholly or even in largest part due to a poisoning effect. Rather, we are inclined to think toxicity one of several causes, awaiting more crucial experiments before attempting to say how large a part it plays in the malign influence of grass.

GENERAL REMARKS ON TILLAGE AND SOD IN AN ORCHARD.

The first report of this experiment has called forth many questions and some objections which are not answered in the main body of this report. It seems worth while to attempt to touch upon the most important of these here.

In deep, fertile soils where trees have a deeper root-run than in the shallow soil of the Auchter orchard, competition between apples and grass may be less keen and the grass therefore less harmful.

There is nothing in this experiment to show that apple trees eventually "adapt" themselves to grass — a statement often heard. The sodded trees showed harmful effects from grass as soon as sod formed and in every plat. The longer the trees remained in sod the more exhausted and decrepit they became.

There are orchards in which, paradoxically enough, ill-treatment may prove beneficial. Thus, it is common knowledge that checking a tree which is luxuriating in growth may make it more fruitful. In rich, moist soils, then, sod may be beneficial as a permanent treatment for an orchard. So, too, in an orchard such as the one in which this work has been carried on, grass, in an occasional homeopathic dose, might prove valuable.

The question is often asked as to whether sod will have the same deleterious effect on other tree fruits that it has on the apple. Observation leads us to answer in the affirmative. Indeed, with peaches and plums at least, harm is done even more quickly and is more serious.

Occasionally we hear objections to the general application of our results on the ground that we have worked with but one variety — the Baldwin. To such objection we reply that the all but fatal effects of grass may be seen in innumerable orchards in New York quite regardless of variety, age of tree, whether dwarf or standard, or of cultural treatment, as spraying, pruning and the like.

The effect of sod on dwarf trees, the roots of which are much nearer the surface than those of standards, must in most situations be even more serious than on the trees in this experiment — a fact to be borne in mind by amateurs in planting in door-yards which are usually in grass.

Orchardists who pasture hogs, sheep or cattle in their plantations very generally hold that their trees behave differently than do those in our experiments. We have taken pains to visit many such orchards and have yet to find one in which cannot be recognized in greater or less degree the earmarks of grass injury.

Since the publication of the first report on the Auchter orchard many men whose trees are in sod have told me that they could not discover the evil effects of grass so apparent in our work. In most such cases there were no means of making comparisons — tilled trees were not at hand. Within my observation whenever men with sodded orchards in western New York have plowed, tilled and used a cover-crop in a part of their orchard, they have needed no further argument for tillage. The complaint is becoming very common that continuous tillage with leguminous cover-crops produces too many poorly colored apples. How best to avoid this

is a problem yet to be solved, but helpful means in securing more highly colored apples are earlier cessation of tillage, non-leguminous cover-crops and the withholding of nitrogenous fertilizers.

It is a most significant fact that apple-trees can be well-grown in nurseries only under the highest tillage. A nursery in sod is a sight never seen. It would be strange if the plant behaved differently when transplanted in an orchard.

IN CONCLUSION.

We have been considering grass left as mulch in an orchard — bad enough! But grass cut as hay, left to ripen, or pastured by hogs, sheep or cattle is worse. Grass makes apple-trees sterile and paralyzes their growth — it is the withering palsy of the apple industry in New York. It is the chief cause of the decrepit, somnolent, moribund orchards to be seen from the roadsides and car windows in all parts of the State. Cider mills and evaporators thrive on sod-grown apples. The small, gnarly, low-grade apples sent to the markets from orchards in sod have so displeased the eye and palled the appetite of consumers that they are bringing discredit to the apple industry of the State. The average orchard in sod is a liability rather than an asset to its owner. Apple-growing is going out of fashion in New York wherever sodded orchards are in fashion. These are not loose generalities; neither are they rhetorical over-statements. They are cold facts written under earnest conviction of their truth from state-wide observations covering several years. They can be verified by any open-eyed man in a day's travel in any of the apple regions of the State.

TEN YEARS' PROFITS FROM AN APPLE ORCHARD.[1]*

U. P. HEDRICK

INTRODUCTION.

Most men grow fruit for the money to be made. In common parlance they are practical business men. Yet in this day in which efficiency is the slogan of business, not many fruit-growers have precise knowledge of what their capital and labor are accomplishing. As a class, it is not to be supposed that those who grow fruit are more than others wilfully negligent of money matters, but, lacking data with which to start and method with which to keep track of the outgo and income of their orchards, and because of special difficulties, life spins past with the business affairs of most fruit-growers in a tangled skein which they hardly dare attempt to unravel.

COST OF PRODUCTION DATA NEEDED BY INVESTORS.

Everywhere men from city and town are planting orchards — beginners embarking upon what seems to be a pleasing hobby and yet one capable of giving a living and an income for old age. But if their ventures are founded on the figures seen in print or on the occasional phenomenal crops that nearly every orchard bears, the chances are they will find the times out of joint long before their plantings come into bearing and will take to building aerial castles in some other profession. They will learn through experience dearly paid for that many of the cocksure statements read or heard are "but the stuff dreams are made of." Thousands of newly fledged fruit-growers who are now drawing checks on the bank of expectancy, will leave money in, rather than take it from, the field of horticulture. They might not have been thus deluded had there been anywhere a substantial body of figures from which could have been obtained a true conception of the financial conditions of fruit-growing.

ORCHARDING A BUSINESS.

We are well justified in saying that with increasing competition, manifold uncertainties in orchard conditions, and unbusinesslike

[1] Also presented, in essentials, before Western New York Horticultural Society, Rochester, N. Y., January 28, 1914.

* Reprint of Bulletin No. 376, March.

Plate LIII.—Harvest Time in the Auchter Orchard.

administration, fruit-growing is becoming a more and more risky business. Of this you need to be reminded rather than informed. Experience and the teachings of years have given the old hands in fruit-growing, at least, knowledge of the uncertainties in growing fruit, and now everywhere we are hearing discussions of the business side of the industry. Temporarily the "idea of making two blades of grass grow where one grew before," with which agriculture has been chiefly concerned in the immediate past, is eclipsed by the conception, just beginning to be realized, that agriculture is a rather highly developed enterprise requiring for success careful business management.

ACCURATE DATA DIFFICULT TO SECURE.

This Bulletin is presented with the hope that it may prove a helpful contribution to those who want data on the cost of producing apples and on the yields, selling price, and profits in the culture of this fruit. Neither time nor material, however, suffices for anything like a full consideration of the subject; for keeping accounts in apple-growing is a difficult and complicated piece of business. The yearly inventory and striking of balances which do very well for the grocer and butcher do not begin to tell the whole story in fruit-growing. In growing apples, for instance, it takes several years to bring an orchard into bearing, after which it barely maintains itself for a decade or two; the lean years and fat years are more accentuated than in most other industries; advantages and disadvantages are exceedingly changeable; and the value of the investment is variable.

ORCHARD PRODUCTION MUST BE STUDIED BY PERIODS.

The only possible way to obtain an absolutely accurate reckoning of the profits and losses of an apple orchard is to add up the expenses for the whole life of the trees and subtract from the total income; the remainder, if plus, is the profits; if minus, as often will be the case, the losses. This plan in the short span of human life will not work. Since annual accountings are not fair, and total ones not possible, we must divide the life of the orchard into periods and take data for each division. In New York, where the apple tree lives as long as man, we may make from the life of an orchard

seven periods of a decade each; these ought to make very fair units for the collection of data.

DATA FOR ONE PERIOD MAY BE USEFUL.

Unfortunately we do not have for any one of the seven periods much accurate data either as to the average total cost of production or the cost of any one of the several orchard operations, nor do we know much about the average cost of the materials used in orcharding, or the average selling price of the produce of the orchard. Now the value of such data is obvious to those who are making any attempt to keep track of the finances of their business and the object of the present paper is to put you in possession of figures that, rightly used, ought to be helpful. "Rightly used," because most figures are capable of several interpretations and all are subject to the lapses and mistakes common to erring mortals.

COST OF APPLE PRODUCTION IN AUCHTER ORCHARD

CONDITION OF ORCHARD.

The fruit to be considered is the apple as grown in an orchard situated a few miles west of Rochester, known to many as the Auchter orchard, in which the Geneva Experiment Station has carried on a comparative test of sod mulch and tillage during the past ten years. Added value is given to the figures to be presented by the fact that the orchard was selected for experimental work because it was as typical as could be found in the great apple belt of western New York. The trees are Baldwins, 27 years old at the beginning of the experiment, 37 now. The accounts tell what each of the orchard operations has cost, the number of bushels of fruit produced, and the selling price — something substantial to show what the outgo and the income of a New York apple orchard are, in its fourth decade, the period just preceding prime of life. The data, as far as possible, are given for three units, the barrel of apples, the tree and the acre.

AVERAGE YIELD.

The first information we must have in getting at the problem before us is the number of barrels of apples per acre per year. The exact number for the cultivated plat in this ten-year average is

116.8 barrels. Graded, the acre average for the period is 79.2 of barreled stock, 37.6 barrels of evaporator and cider stock. Reducing these figures to the tree unit we have for barrel stock 2.93, for evaporator stock 1.4; or total per tree, 4.33 barrels. The proportion of evaporator and cider stock is seemingly high — made so by two autumn gales in different seasons which gave many windfalls. Such episodes come in the life of every orchard. Yields per acre will vary greatly with the same variety in different orchards even in the same section but there is little reason to think that the ten-year acre average just given is much above the mark for orchards that are cared for — well tilled, sprayed and pruned plantations. It is of course much greater than the average yield of Baldwins in New York for the reason that many orchards are wholly or partially neglected. The annual yields are shown in Table I.

Table I.— Annual Yield of Fruit in Auchter Orchard for Ten Years.

Year.	Per tree.			Per acre.		
	Barreled apples.	Culls and drops.	Total yield.	Barreled apples.	Culls and drops.	Total Yield.
	Bbls.	*Bbls.*	*Bbls.*	*Bbls.*	*Bbls.*	*Bbls.*
1904	2.45	2.13	4.58	66.53	58.08	124.61
1905	1.42	.74	2.16	38.59	20.12	58.71
1906	2.67	1.44	4.11	72.69	39.12	111.81
1907	2.41	.88	3.29	65.53	23.79	89.32
1908	4.18	1.41	5.59	113.85	38.25	152.10
1909	2.37	1.64	4.01	64.63	44.57	109.20
1910	1.92	.69	2.61	52.21	18.80	71.01
1911	3.41	2.19	5.60	92.84	59.60	152.44
1912	3.86	1.70	5.56	105.05	46.17	151.22
1913	4.41	1.02	5.43	120.00	27.62	147.62
Totals	29.10	13.84	42.94	791.92	376.12	1,168.04
10-Year average	2.91	1.38	4.29	79.19	37.61	116.80

INTEREST ON INVESTMENT.

The first item in cost of production to be considered is interest on investment — an entry in the account over which there can be much disagreement. Unfortunately we do not know how much money has been spent in bringing this orchard to its present con-

dition and can only assume that the amount invested is approximately what the present valuation is. What is a Baldwin orchard, in full bearing in the prime of life, worth? Sales are too few and most of those that take place are made under conditions too abnormal to make selling price a safe gauge of value. We will suppose the value to be $500.00 per acre and the interest five per ct. This valuation is not high, for it includes not only cost of land, trees and labor, but the deferred dividends of the first twelve or fifteen years. It is sufficient, too, to cover the overhead expense of houses and barns — or at least the share of these changes that would fall to a ten-acre orchard in New York. The first expense item, then, is $25.00 per acre on investment, a sum which, divided by 116.8, the number of barrels per acre, gives a charge per barrel of 21 cents as interest on investment.

TAXES.

Taxes vary greatly in different counties as they do somewhat in different years in the same county. Since this orchard is but a part of a general farm, only an estimate can be made of the cost of taxes. There are few regions or years in New York in which taxes for such an orchard would be over $1.50 an acre, making the tax on each barrel of apples 1.2 cents.

DEPRECIATION OF OUTFIT.

The next account to be charged to cost of production is depreciation in teams and tools and interest on the money invested in them. First-class machinery for running the average orchard will cost in the neighborhood of $1,000, the items being as follows: team $400, spraying outfit $250, harness $50, wagon $75, plow, harrows, ladders, crates, pruning tools, etc., $115. The figures named are below rather than above average prices but there are few instances, indeed, in which the tools and teams named would be used exclusively for a ten-acre orchard. If we set the depreciation and interest on money at 20 per ct. for the above equipment, we must add 17 cents. per barrel of apples to the depreciation account. Take notice that in obtaining the cost of production in the Auchter orchard the depreciation account must be thrown out, for the Station hired all work done and the workmen furnished their own teams and tools. This item is put in, then, only as an approximation of what men who are doing their own work must charge for depreciation.

COST OF TILLAGE.

Passing now to orchard operations the annual cost of tillage per acre for the decade was $7.39, making the amount to be charged against each barrel of fruit 6.3 cents. Tillage consisted, in this orchard, of plowing the ground in the spring, after which it was harrowed, rolled and then cultivated by harrowing an average of seven times per season. The price paid for team work at the beginning of the period was $4.00 per day of 10 hours; but the price advanced to $5.00, a fair average being $4.50. Tillage includes the labor of putting in the cover crop but not the cost of the seed. For the cover-crop seed, in this orchard, usually red clover, must be added $2.74 per acre for seed or 2.3 cents per barrel of apples.

COST OF PRUNING.

The expense of pruning per year per acre was $3.56 — since there are 27 trees to the acre in this orchard the cost per tree was 13.1 cents. The cost per barrel of apples was 3 cents. The average price paid for the work was $2.00 per day oi 10 hours.

COST OF SPRAYING.

The average cost per acre for spraying was $11.28; per tree 41.8 cents; per barrel of apples 9.6 cents. The spraying was done the first few years with a hand sprayer, then for several years with a Niagara gas sprayer and the last three with a gasoline power outfit having two runs of hose. The first five years bordeaux mixture and arsenite of lime were used; the last five, lime-sulphur and arsenate of lead. The orchard was sprayed three times per season the first five of the ten seasons. The second five years it was sprayed but twice per season, the first application being the dormant spray made just before buds began to swell; the second just as blossoms dropped. This treatment has given an almost perfect crop, wormy and scabby apples being rarities scarcely to be found in the orchard.

EXPENSE OF SUPERINTENDENCE.

The last of the cost of production charges is that of superintending the work. The services of the average fruit-grower are worth more than the $2.00 per day allowed for actual work and this defici-

ency should be made up by a charge for superintending the work. The Station paid for this service $300 per year. This is a fair price since there are few competent orchardists who could not superintend a farm enterprise of several times the magnitude of a ten-acre orchard. The charge to be entered against a barrel of apples then for superintending is 25 cents; against the acre unit, $30; against an apple tree $1.10.

HARVEST EXPENSES.

Picking, packing, sorting and hauling have been done in diverse ways during the ten years and the items cannot be segregated. But the total cost of these operations has been 24.4 cents per barrel. The apples, it should be said, were sorted and packed in the field. The crop was hauled to a station one and a half miles away over a country road not better than the average.

The following is a summary of the cost sheet for a barrel of apples:

Interest on investment	$0.21
Taxes	.012
Tilling	.063
Pruning	.03
Spraying	.096
Cover crop	.023
Superintending orchard	.25
Picking, packing, sorting and hauling	.244
	$0.93

COST OF BARRELS.

All of the first and second-grade apples from the Auchter orchard have been packed in barrels. The average price of barrels for ten years has been 36 cents each; the price fluctuated from 30 cents to 40 cents. The culls have been handled in crates and a charge for packages cannot be entered against them. Adding the cost of the barrel to the cost of production we have $1.29 as the total cost of a barrel of apples at the shipping point.

Table II.— Annual Cost of Tillage, Cover-crop Seed, Pruning, Spraying, Harvesting and Price of Barrels in Auchter Orchard for Ten Years.

Year.	Tillage.	Cover-crop seed.	Pruning.	Spraying.	Harvesting (inc. bbls.).	Price of barrels.
1904	$21.25	$12.50	$14.62	$58.22	$210.90	$0.375
1905	34.11	14.60	13.25	44.27	96.85	.30
1906	24.00	6.30	15.12	46.51	231.80	.32
1907	29.13	17.50	18.31	73.84	224.20	.40
1908	28.87	7.80	22.11	50.45	338.59	.36
1909	52.91	7.94	16.69	61.75	229.91	.35
1910	39.70	15.45	13.62	49.70	183.89	.35
1911	44.00	17.91	14.25	51.97	373.20	.35
1912	35.00	21.89	19.50	52.84	415.51	.40
1913	42.25	8.25	21.87	46.35	415.24	.40
Total	$351.22	$130.14	$169.34	$535.90	$2,720.09	$3.605
Average per barrel	.063	.023	.03	.096	.604	.36
Average per tree	.27	.10	.131	.41	2.10	....
Average per acre	7.39	2.74	3.56	11.28	57.26	....

RETURNS FROM AUCHTER ORCHARD.

PRICE OF APPLES.

We come now to the average price of apples for the past ten years as grown in the Auchter orchard. We have received an average of $2.60 for all the barreled stock sold, which includes firsts and seconds. For evaporator and cider stock we have received 72 cents per barrel, rather above the average, possibly, because in two seasons gales of wind, as has been said, gave an abnormally large quantity of very good windfalls. The yearly prices received appear in Table III.

Table III.— Price per Barrel Received for Apples in the Auchter Orchard for Ten Years.

Year.	Barreled apples.	Culls and drops.	Year.	Barreled apples.	Culls and drops.
1904	$1 41	$0 26	1909	$3 35	$1 11
1905	2 80	66	1910	3 35	1 08
1906	2 00	34	1911	2 50	1 02
1907	3 50	79	1912	2 00	60
1908	2 25	37	1913	3 00	97
Average	....	....	....	$2 61	$0 72

YIELDS.

As stated on page 84, the average yield of the orchard for the ten years has been 79.2 barrels of barrel stock per acre, and 37.6 barrels of evaporator and cider stock.

BALANCE SHEET.

We are now ready to calculate profits and declare dividends: Subtracting $1.29, the cost of a barrel of apples, from $2.60, the amount received, a net profit of $1.31 per barrel remains for firsts and seconds. Multiplying by 79, the number of barrels per acre, gives $103.49 as the profit per acre for firsts and seconds. Subtracting 72 cents from 93 cents, gives 21 cents as the difference between average cost of production and average selling price of culls. Multiplying 37.6, the number of barrels of culls per acre, by 21, gives a loss of $7.89 per acre on the culls, leaving the average net profit per acre in this orchard for the past ten years $95.60; add to this the $25 interest on the investment and we have $120.60 net, or 24.12 per ct. on $500, as the annual ten-year dividend from this orchard.

GENERAL STATEMENTS.

In closing, several general statements must be made:

The first of these is that the pan has not been skimmed in the Auchter orchard work and the milk that is left is equally as good as that which was taken. This orchard, barring accidents, will do as well, or rather better, during the next twenty years than it has in the past ten.

Secondly, as good or better dividends are coming from many New York apple orchards similarly situated and similarly cared for. The figures given are a fair average for a Baldwin orchard in its fourth decade. The cost of production is, if anything, high, since the State cannot do work as cheaply as an individual. The extra cost, if such there be, has been offset, however, by the skill and efficiency with which Mr. Auchter, in direct charge of the work, has managed every detail.

Third, the profits of this orchard are probably many times as great as those from the average plantation in New York. Indeed,

if the financial history of every apple tree in New York could be written it would be found that the total cost of all quite equals the receipts from all — in other words, many are losing and few are winning. This is the history of financial endeavors in all industries.

A TEST OF COMMERCIAL FERTILIZERS FOR GRAPES.*

U. P. HEDRICK AND F. E. GLADWIN.

SUMMARY.

1. There has been a decline in yields of grapes in the Chautauqua Grape Belt, the chief grape-growing region of New York. This bulletin is a report of several experiments to determine the value of commercial fertilizers in increasing or restoring former yields.

2. The experiments under discussion were carried on in a leased vineyard near Fredonia, New York, and in six vineyards in various parts of Chautauqua County in which cooperative work was carried on with the owners. The vineyards were selected to obtain fair averages of soils and of health and vigor of the grape plantations of this region.

3. The treatments consisted of annual applications of nitrogen at the rate of from 56 to 72 pounds per acre; phosphorus from 18.3 pounds to 25.3 pounds per acre; potassium from 52.7 pounds to 59.3 pounds per acre; and lime at the rate of 2000 pounds per acre. The nitrogen was applied in nitrate of soda, dried blood and cottonseed meal, the phosphorus in acid phosphate and the potassium in sulphate of potash.

4. The results of the experiments are gauged by yield of fruit, effects on the fruit, effects on the foliage and effects on the wood. A brief summary of the results in the Fredonia vineyard is:

Nitrogenous fertilizers had a marked beneficial effect upon the yield and quality of fruit and upon leaf and wood growth, making it certain that nitrogen is the limiting factor in this vineyard.

Lime had no appreciable effect in this vineyard and phosphorus and potassium had so small a beneficial effect that their use was not profitable.

5. In the cooperative experiments not only commercial fertilizers but stable manure and green manure crops were used. The results from the use of all are confusing and unsatisfactory, varying greatly in any one vineyard or in the several vineyards compared with one another.

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* Reprint of Bulletin No. 381, March; for Popular Edition see p. 920.

Plate LIV.—View in Experimental Vineyard at Fredonia.

6. From the data obtained in these experiments it is evident that the fertilization of vineyards is so involved with other factors that only long continued work will give reliable results. From the work done, however, several suggestions may be made to grape-growers:

First, fertilizers can not be profitably applied in vineyards poorly drained, suffering from winter freezes or spring frosts, or in which fungi or insects are uncontrolled, or where good care is lacking.

Second, it is probable that most vineyards have a one-sided wear, there being few plantations indeed where more than one or two of the elements of fertility are lacking. Nitrogen is probably most frequently the element needed. Each grape-grower should try to discover which of the food elements his particular soil needs, if any.

Third, maximum profits cannot be obtained in many vineyards of the Chautauqua Belt because of the lack of uniformity in vineyard conditions. Grape-growers should strive by every means possible to secure an equally vigorous and healthy growth over the entire area cropped.

Fourth, the steps to be taken in restoring a failing vineyard are, in the usual order of importance, 1st, give good drainage; 2d, control insects and fungi; 3d, improve the tillage and general care; 4th, apply such fertilizers as may be found lacking.

INTRODUCTION.

THE CHAUTAUQUA GRAPE BELT.

The Chautauqua Grape Belt, the largest and most important area in which native grapes are grown in America, consists of a narrow strip of land along the southern shore of Lake Erie, varying in width from two to five miles, extending from Derby, New York, on the east, to Erie, Pennsylvania, on the west, approximately sixty-five miles. The grape industry in this belt is about thirty-five years old. Starting with small and scattered vineyards a steady increase in acreage has followed until now nearly 40,000 acres are planted to grapes. The U. S. Census Bureau reports 12,930,000 grape vines in Chautauqua and Erie counties in 1899 and 16,924,000 in 1909, a thirty-per-ct. increase.

A DECLINE IN YIELDS.

As the industry grew there should have followed a proportionate increase in tonnage. In other words, if 30,000 acres yielded 96,000 tons in 1900, 40,000 acres should have yielded 128,000 tons or thereabouts in 1913. But with the increased acreage there has followed only a slight gain in tonnage. Table I, from data collected and compiled in the office of "The Grape Belt,"[1] shows the total production in car loads shipped or used locally for the period from 1900 to 1913 inclusive.

TABLE I.— GRAPE PRODUCTION IN CHAUTAUQUA BELT, 1900–1913.

1900 (estimated) . . .	8000 cars	1907	5186 cars
1901	6669 cars	1908	4323 cars
1902	5062 cars	1909	7561 cars
1903	2952 cars	1910 (estimated) . . .	5700 cars
1904	7479 cars	1911	8100 cars
1905	5362 cars	1912	7528 cars
1906	5364 cars	1913	3957 cars
	40888 cars		42355 cars

A study of Table I discloses the fact that notwithstanding a greatly increased acreage, during the period beginning with 1900, the yields have been considerably less in many years and in only one, 1911, has it been larger. The total yield for the last half of the period is thus only $3\frac{1}{2}$ per ct. greater than that of the first half.

WHY HAVE YIELDS DECREASED?

Undoubtedly the chief reason for the failure of the yield to keep pace with the acreage has been the planting of vineyards on soils unfitted for the grape because of thinness, infertility and poor drainage. Vineyards planted under any of these conditions were doomed to failure from the beginning. But there are also many old and young vineyards on good soils that are not producing profitable annual crops, indicating that something beside the soil is amiss. On these good soils two or three fair crops are often harvested and yields then diminish. Many plantings that a few years ago promised well, today are but average vineyards, or must even be classed as poor.

[1]A semi-weekly paper published at Dunkirk, N. Y.

Further examination of Table I shows that yearly yields are exceedingly variable. A year of large yield is usually followed by short crops for two or three years; these in turn are succeeded by another yield considerably above the average. These variations are attributed to many causes, among which are severe winters, late spring frosts, summer drouths, cold, wet weather during the growing season, insect depredations and lack of fertility. Undoubtedly any of the causes ascribed could materially affect the yield but it is certain that decreasing yields in all vineyards are not due to the same causes. Furthermore, vineyards that are in a weakened condition because of some obscure trouble are less able to stand low temperatures, drouths, and insect invasions, some one of which are of almost annual occurrence. Again, some vineyards produce very fair annual crops even though subjected to several unfavorable conditions, while others, seemingly under the same influences, are unprofitable.

AN EFFORT TO STOP THE DECREASE.

This Bulletin presents part of the results of five years of work by this Station in an effort to find out how the decreasing yields can be checked. Experiments in the control of insect and fungus pests and with commercial fertilizers, stable manure, green manures and lime have been made. The present report is an account of the experiments with commercial fertilizers.

A VINEYARD SURVEY.

In order to obtain at first hand the experiences of vineyardists with commercial fertilizers and stable manures, the junior author made a farm-to-farm survey in 1909. Growers of grapes to the number of 482 were interviewed and in most instances their vineyards were examined. The following statements sum up the information obtained pertinent to the subject under discussion.

The use of commercial fertilizers has been and is an extremely irregular practice, irregular not only as to frequency of application, but also as to the carriers and the elements used. Of the 482 growers interviewed, only 46 had used commercial fertilizers in 1904, 49 in in 1905, 102 in 1906, 107 in 1907 and 178 in 1908; or in all 252 used commercial fertilizers one or more years during the five for which

data were collected. It will be seen also that there has been an increase in the number using fertilizers during the five-year period and it is very probable that the increase has been proportionately greater during the past four years. Of the 252 reporting as having used some form of commercial fertilizer only 89 applied a complete one. Seventy used kainit alone, 45 ammoniated bone, 28 tankage, 20 raw ground bone, 17 potash and acid phosphate, 10 bone and kainit and 10 bone and muriate of potash. Quickly available forms of nitrogen have been used in but few instances. The amounts applied, viewed in the light of our tests, have generally been much too small to be very useful. It was interesting to note that many believed they had obtained decided results from the use of commercial fertilizers, while others secured no favorable effects.

Usually immediate returns were expected and failure to get them resulted in a change of materials or a discontinuance of the use of fertilizers. Some growers seem to have gone on the theory that fertilization is a substitute for tillage. The data seemed to show, considered broadly, that growers who had used commercial fertilizers regularly, other conditions being the same, had secured less variable crops from year to year, than those who had made irregular and scant applications or none at all.

The survey disclosed similar irregularities in the use of stable manure but indicated that more confidence is placed in its use by vineyardists than in commercial fertilizers. But little stock is kept in this region, however, and not nearly enough manure is produced to enrich vineyards, while the cost of importing is almost prohibitive. The usual plan in manuring is to go over a portion of the vineyard one year, another the next, and so on until all has been fertilized. This practice often requires a long period to cover a vineyard. Usually two or three forkfuls are thrown around the base of the vine, to be spread by the plow or cultivator. These amounts are not sufficient nor the mode of application such that the vine can utilize the manure at maximum efficiency.

The vineyard survey made at the beginning of the work in Chautauqua county clearly showed two things: First, that lack of fertility is a contributing cause in the decline of vineyards. Second, that fertilizing practices were very diverse and the results uncertain.

STATION WORK IN GRAPE BELT.

IN THE EXPERIMENTAL VINEYARD.

In the spring of 1909 this Station leased the 30-acre farm of H. B. Benjamin, Fredonia, New York. The soil on the Benjamin farm is of three types: Dunkirk gravelly loam, Dunkirk silt loam and Dunkirk clay loam. The fertilizer experiment was located on the gravelly loam, described as follows:

The Dunkirk gravelly loam is a deep, open soil quite inclined to leaching. It is formed of alternating layers of varying degrees of fineness. In the Benjamin vineyard it extends to a depth of approximately 20 feet. This type of soil is generally preferred by vineyardists in the Chautauqua Belt, not by reason of superiority in its plant food content nor because grapes are grown better on it but rather because it is naturally well drained and more easily worked. It consequently commands a higher price per acre. In 1909 about one-third of the entire acreage of the Chautauqua District was located on Dunkirk gravel and Dunkirk gravelly loam. Since then, however, the plantings have been largely on other soil types as practically all land of this type had previously been planted to grapes or other fruits.

Chemical analyses of this type of soil, collected from the check plats of the experiment, are given in Table II.

TABLE II.— SUMMARIZED CHEMICAL ANALYSES OF DUNKIRK GRAVELLY LOAM SOIL ON UNFERTILIZED PLATS, BENJAMIN FARM, FREDONIA, N. Y.
Calculated to pounds per acre

Section.	Depth of sampling.	K_2O.	K.	P_2O_5	P.	CaO.	Ca.	MgO.	Mg.	N.
	Ins.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
4........	0– 7	44,600	36,800	3,940	1,720	12,800	9,000	16,200	9,600	3,200
4........	7–14	47,400	39,200	2,860	1,240	14,400	10,200	18,400	11,000	1,700
5........	0– 7	41,400	34,200	2,640	1,140	13,600	9,600	15,800	9,600	2,520
5........	7–14	45,400	37,600	2,380	1,040	13,000	9,200	15,800	9,600	1,480

THE FERTILIZER SECTION.

A section of approximately three acres was selected for the test of commercial fertilizers. This area is very uniform and has a gentle slope to the south. A slight depression extends across the

entire section from west to east. The plats extend at right angles to this depression so that the topography is uniform. The soil on the north side is possibly a little lighter than elsewhere in the section but the same extent of each plat overruns this variation. The rows, 46 in number, run north and south and contain 37 vines per row. A few scattering vines have died and not all are yet replaced. The vines in this section were approximately 18 years old when this experiment was begun in 1909. At this time it was a representative vineyard for this type of soil, except that the west portion, including about 20 rows, was in poor condition. Plats 1, 2 and 3 fell in this poorer part.

As far as could be learned no commercial fertilizer nor stable manure had been applied to the vineyard for at least 10 years before the beginning of this experiment. The tillage had been that ordinarily given; namely, spring plowing, horse-hoeing, hand-hoeing and cultivation with the spring-tooth and disc harrow. Spraying had been done intermittently.

This section was divided into 11 plats consisting of 3 rows each, with an " outside " row at each end of the section and a " buffer " or " discard " row between successive plats. The plats were numbered from 1 to 11 in order from west to east. The vines are 8 feet apart each way, making 680 to the acre. Each plat contains 111 vines, about one-sixth acre. In computing the results the producing vines only are counted. Outside of a few scattering vines of Clinton and Catawba the vines are all Concord.

TREATMENT OF PLATS.

Fertilizers were to be applied annually as follows:

Plats 1 and 7.

Nitrate of soda at the rate of 100 pounds per acre.
Cottonseed meal at the rate of 800 pounds per acre.
Acid phosphate at the rate of 300 pounds per acre.
Sulphate of potash at the rate of 200 pounds per acre.
Lime (air slaked) at the rate of 2000 pounds per acre.

Plats 2 and 8.

These plats had the same applications as 1 and 7 excepting that no lime was used.

Plats 3 and 9.

Nitrate of soda at the rate of 100 pounds per acre.

Cottonseed meal at the rate of 800 pounds per acre.
Acid phosphate at the rate of 300 pounds per acre.

Plats 4 and 10.

Nitrate of soda at the rate of 100 pounds per acre.
Cottonseed meal at the rate of 800 pounds per acre.
Sulphate of potash at the rate of 200 pounds per acre.

Plats 5 and 11.

Sulphate of potash at the rate of 200 pounds per acre.
Acid phosphate at the rate of 300 pounds per acre.

Plat 6.

Unfertilized.

After the first year dried blood was substituted for the cottonseed meal owing to the difficulty in obtaining the meal. The amount of dried blood used in 1910 was at the rate of 560 pounds per acre; but in the last three years this was reduced to 400 pounds per acre. The difference was made necessary because of the variability of the nitrogen content of the blood in 1910 and the three years following.

The lime applications have been made at three-year intervals. Thus far two applications have been made, one of air-slaked lime and the other an equivalent amount of ground limestone.

The fertilizers were purchased in the open market at prevailing prices and were "home mixed." Table III gives the prices paid for the materials.

Table III.— Price per Ton of Commerical Fertilizers Used in Grape Fertilizer Experiments.

Commercial fertilizers.	1909.	1910.	1911.	1912.	1913.
Nitrate of soda	$54.00	$49.25	$49.00	$50.00	$56.00
Dried blood	39.50	40.00	55.00	55.00	40.00
Cottonseed meal	24.75	....	....	....	....
Acid phosphate	13.00	13.00	13.00	13.00	11.00
Sulphate of potash	47.00	45.00	48.00	48.50	45.00

The lime was broadcasted and harrowed in after spring plowing. In 1909 the cottonseed meal and nitrate of soda were mixed with the other materials, broadcasted and plowed under; but in the

following years the dried blood and nitrate of soda were withheld from the mixtures and two applications of them made, one shortly after growth started and the second two or three weeks later. In both, the fertilizer was broadcasted and lightly harrowed in. The acid phosphate and sulphate of potash were applied early and plowed under.

Using these materials at the rates just given, in 1909 we applied 72 pounds of nitrogen, 25.3 pounds of phosphorus (58 pounds of phosphoric acid), and 59.3 pounds of potassium (108 pounds of potash) per acre. In 1910, 1911, 1912 and 1913 we applied 56 pounds of nitrogen, 18.3 pounds of phosphorus (42 pounds of phosphoric acid), and 52.7 pounds of potassium (96 pounds of potash).

COVER CROPS.

Table IV shows the cover crops that have been used in this experiment, the rates of seeding, the dates of seeding and the time they were turned under.

TABLE IV.— COVER CROPS USED IN GRAPE FERTILIZER EXPERIMENTS.

Year.	Crop.	Amount of seed per acre.	Date sown.	Date plowed under.
1909	Rye	1 bu	Aug. 4	April 19
1910	Barley and cowhorn turnips.	1 bu barley, 12 oz. turnip	July 28	April 26
1911	Cowhorn turnips	1½ lbs.	July 24	May 15
1912	Winter wheat	1 bu	July 31	April 29
1913	Cowhorn turnips	2 lbs.	July 28	....

The time of sowing depended largely upon the amount of moisture in the soil. The cover crops were turned under at the time the soil was fit for working, though if the growth was not large the plowing was delayed a little. Ordinarily the three-gang plow was used in turning the crop under but if the work could not be thoroughly so done, a two-horse plow with a chain was employed.

CULTIVATION.

The first detail of cultivation each year was the turning under of cover crops. The plowing was up to the vines one year and the

next away from them. After plowing, a spring-tooth harrow was used, though if the cover crop were heavy the plow was followed by a disc harrow. In 1913 the wheat was disced before and after plowing with good results. Horse-hoeing followed harrowing and was done considerably earlier than is the usual practice. After horse-hoeing the section was thoroughly hand-hoed. From this time on until time for sowing the cover crop the vineyard was harrowed about every ten days, depending upon the frequency of heavy rains. The aim was to keep a dust mulch throughout the growing season. Just before the last cultivation, a ridge was thrown up to the vines by the horse-hoe with the blade reversed.

PRUNING AND TRAINING.

The Chautauqua System of training, common to the Chautauqua Belt, was used throughout this experiment. The method is described in Circular No. 16 from this Station. The same man has done the pruning during the five seasons. He was instructed to disregard differences in plat treatment and to prune solely according to the vigor of each vine. If a vine had made a good growth of well ripened wood, it was pruned to four canes; if but fair growth, it was pruned to two or three canes; but if the growth was poor all fruiting wood for the succeeding crop was cut away. In certain years, as every grape-grower knows, the wood is "short-jointed" and in others "long-jointed" or medium. In the years of "short-jointed" wood fewer canes per vine have been reserved for fruiting. If the internodes were long, the number of canes was increased. Pruning was done as soon as the leaves were off and the weight of the wood from each plat was taken as the work progressed.

SPRAYING.

The number of times the vineyard was sprayed was determined by the prevalence of insects and fungi. All plats were sprayed alike. The principal insects combated were the grape root-worm and the grape leaf-hopper. Powdery mildew was the only fungus requiring treatment. Bordeaux mixture and arsenate of lead were the materials used for the root-worm and the powdery mildew, while "Black Leaf" tobacco extract was used for the grape leaf-hopper.

WEATHER CONDITIONS DURING THE FIVE YEARS.

Table I shows that the 1911 crop was the largest since 1900, with the 1909 crop but slightly less. A part of the increase can be accounted for through increased acreages, but the average tonnage per acre in the old vineyards was generally considerably greater than that for several years previous. Vineyardists were of the opinion, after the large crop of 1909, that the era of low yields and poor wood growth was past. However, when pruning time came, it was seen that while wood growth was ample, it was not, as a rule, well ripened. That this was the case was further shown at the time growth started in the spring of 1910 when it was found that approximately 50 per ct. of the buds that were to bear the crop of that year were dead. The opinion prevailed that late spring frosts had killed them. In the opinion of the authors, however, the injury came indirectly from the heavy crop of 1909, which delayed bud maturity, making the buds tender, and as a result they were killed by cold. In this connection the weather conditions of the winter of 1909–10 are worth noting.

The latter half of December, 1909, was an unbroken period of cold weather with a minimum temperature of 5 degrees below on December 29th. Once during the month of January, 1910, the temperature dropped to 2 degrees and again to 10 degrees below in February. The last freezing temperature of 1910 was on May 12 and while the buds had started slightly, they were uninjured in a young vineyard nearby that had borne but a small crop in 1909 and in which the wood and buds were well ripened. Whether bud injury was due to severe temperatures or late spring frosts is immaterial but it should be emphasized that well ripened wood and buds were able to withstand both conditions.

The fall and winter temperatures following the large crop of 1911 were characterized by frequent and decided changes. January, 1912, was the coldest on record, —15 degrees and —19 degrees being recorded. The cold weather continued until the middle of February and after that another severe cold period occurred in March. The soil froze to unusual depths. The grape crop in 1912 in the old vineyards fell considerably below that of 1911. The wood growth for the season was very scanty and examination disclosed many injured buds. The crop of 1913 was the lightest since 1903.

Thus, winter temperatures, coupled with immature wood and buds, have influenced the yields to a large degree in two of the five years that this experiment has been running.

GAUGING RESULTS.

During the first two years, 1909 and 1910, records were made of the fruit yields from the different plats and of the vigor of the vines as indicated by the wood growth and the amount and color of the foliage. For the past three years, weight of pruned wood, leaf weight (green and dry), amount of bearing wood, size of fruit clusters, size of berries, compactness of bunch, and time of maturity of fruit were also recorded for each plat.

YIELD OF FRUIT.

In Table V are given the amounts of fruit borne the past five years, beginning in 1909. Records of individual vines were not kept. The total production of each plat was recorded and from these the average yield per vine was obtained. The yields per acre are computed in tons and are net. The table shows that in 1909 the unfertilized check yielded less than any plat in the experiment, ranging from three-hundredths of a ton less in one instance to one and seventy-nine-hundredths tons less in another. On either side of the check plat the yields, with one exception, are considerably greater than in it. The exception is in the plat to which no nitrogen was applied. Differences in wood growth or in the color of the foliage in any of the plats were not discernible in 1909.

TABLE V.— YIELD OF GRAPES (TONS PER ACRE) IN FERTILIZER EXPERIMENTS.

Plat No.		1909.	1910.	1911.	1912.	1913.	5-yr. av.
		Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1	Complete fertilizer; lime....	4.48	2.10	5.37	3.46	2.14	3.51
2	Complete fertilizer........	4.76	2.21	5.71	4.30	2.83	3.96
3	Nitrogen and phosphorus...	5.17	2.14	5.61	4.00	2.25	3.83
4	Nitrogen and potash.......	4.25	2.55	5.64	4.10	2.85	3.87
5	Phosphorus and potash....	3.41	2.00	5.44	4.35	1.78	3.39
6	Check..................	3.38	2.10	5.32	3.60	1.24	3.12
7	Complete fertilizer; lime....	4.69	2.38	5.62	4.80	3.04	4.10
8	Complete fertilizer........	4.66	2.07	5.71	4.98	2.72	4.02
9	Nitrogen and phosphorus...	4.99	2.04	5.35	4.89	2.61	3.97
10	Nitrogen and potash.......	4.79	2.26	5.91	4.89	3.07	4.18
11	Phosphorus and potash....	4.99	1.87	5.03	4.21	1.97	3.61

During the winter of 1909–1910 approximately 50 per ct. of the buds, as we have seen, were killed. Counts made of injured buds in the different plats showed that the damage was uniform throughout the vineyard and that the fertilizers had not affected hardiness of bud. This condition was reflected, as Table V shows, in the uniformity of yields in the several plats in 1910. Not only were the yields about equal over the entire section for the year 1910 but the small crop, by not taxing the vines, probably served also to equalize the 1911 crop which was as uniformly high as the crop of 1910 was low. Thus the season of 1910 may be considered a rest period. Differences in yield between the check and fertilized plats in both 1910 and 1911 were so slight that they are within the range of accidental variation.

The yield records for 1912, however, show marked differences in the several plats. From them it will be seen that only one fertilized plat, No. 1, to which was applied complete fertilizer and lime, fell below the check. The vines on the part of the section that includes this plat, with the adjacent plats, it will be remembered, were lacking in vigor at the beginning of the experiment. It is probable that their poor condition is reflected in the yields of 1912.

The differences in yield this year between the check and the fertilized plats range from four-tenths of a ton to one and thirty-eight-hundredths tons per acre. The yields over the entire section were above the average for that of the five years.

In 1913, the check plat is, without exception, the lowest producer. The differences between it and the fertilized plats range from fifty-four-hundredths of a ton in the case of Plat 5, phosphorus and potassium, to one and eighty-three-hundredths tons with Plat 10, nitrogen and potash. In this year both of the phosphorus and potassium plats, which up to 1913 produced crops comparable with any of the others, gave lower yields than any other fertilized plats. This seems to indicate that the lack of nitrogen in these plats is beginning to be felt.

The five-year averages for the plats indicate that all have produced more than ordinary crops for the period and while the showing for the check is good, the fact that it dropped behind in 1912 and 1913 probably means that the fertilizers are beginning to tell in the fertilized plats. We shall see that the fertilized vines show improvement as well.

EFFECTS ON THE FRUIT.

No differences were to be detected in the fruit from the various plats in 1909, 1910 and 1911. The grapes in all respects compared very favorably with those in the average well-cared-for vineyard on the same soil type — no better, no worse. Nor were any differences noted in time of maturing. In 1912, however, it began to appear that the fruit from the plats on which nitrogen had been used was superior in compactness of cluster, size of cluster and size of berry. The crop also matured earlier than in the check plats. The grapes in the phosphorus and potassium plats, while superior to those in the checks in these respects, were not equal in quality of fruit to those from the plats which had had nitrogen. The clusters from the check were poorly filled out and both clusters and berries were small. In 1913 these differences, with the exception of earlier maturity, were even more marked. The favorable ripening season and the smaller crop probably tended to equalize the time of maturity between the fertilized and the unfertilized plats. In 1912 ripeness was an important consideration and no doubt the fertilizers played an important part in hastening maturity.

EFFECTS ON THE VINES: THE FOLIAGE

In the growing seasons of 1909, 1910 and 1911 there were no indications of differences in the amount or color of the foliage on the vines on the different plats. In 1912, though, the plats fertilized with nitrogen showed more abundant foliage, which was of better color than that on the other plats, the check showing the poorest foliage of all. During 1913 these differences became more apparent; even the casual observer could easily note them. The check was so inferior to any other plat that one not knowing the experiment would have suspected the presence of disease as the cause of the poor condition. The nitrogen plats were distinctly superior to the phosphorus and potassium plats in amount and color of foliage — more so than in 1912. The years 1912 and 1913, in which these differences in leaf characteristics were first observable, it is remembered, are the years in which marked differences were prominent in fruit characteristics.

TABLE VI.— COMPARATIVE WEIGHTS OF GRAPE LEAVES IN FERTILIZER EXPERIMENTS.

Plat No.	Treatment.	1911.		1912.		1913	
		Green.	Dry.	Green.	Dry.	Green.	Dry.
		Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1	Complete fertilizer; lime....	1,551	660	735	285	995	421.6
2	Complete fertilizer........	1,515	642	745	275	1,010	416.4
3	Nitrogen and phosphorus...	1,632	699	690	265	970	416.0
4	Nitrogen and potassium....	1,677	723	720	265	1,065	413.1
5	Phosphorus and potassium.	1,509	636	640	245	960	410.4
6	Check..................	1,359	585	565	245	865	396.0
7	Complete fertilizer; lime....	.....	.....	760	280	1,135	446.1
8	Complete fertilizer........	.....	.....	765	280	1,115	432.7
9	Nitrogen and phosphorus...	.....	.....	800	320	1,145	463.1
10	Nitrogen and potassium....	.....	.....	835	305	1,050	421.2
11	Phosphorus and potassium..	.....	.....	720	280	990	402.6

Note.— 300 leaves are considered in each determination, 5 being taken from each of 60 vines. The first leaf beyond the last cluster is taken.

It seems reasonable to suppose that differences in foliage existed before they were discernible to the eye and an examination of Table VI indicates that such was the case. This table gives leaf weights, green and dry, of 300 leaves from each plat. These were taken from 60 vines. The first leaf beyond the last cluster was selected from each of five canes, which were located at about the same level for all vines. Owing to other demands at the time only one-half of the plats were calculated in 1911 but the records are complete for 1912 and 1913. Shortly after the leaves were gathered they were weighed. They were then air-dried and reweighed. From this data, it would appear that nitrogen is increasing the size of the leaf.

ANNUAL WOOD GROWTH.

There were no indications either, in 1909, 1910 or 1911, that fertilizers were producing any increases, apparent to the eye at least, in wood growth. In the fall of 1911, as fast as the plats were pruned, the wood was stripped from the wires, taken to the end of the rows and weighed. The weights included the weights of the canes put up for the year previous in each instance. Owing to unfavorable weather but six plats were weighed at this time.

The remaining five were weighed early in the spring of 1912. These are starred in Table VII which gives the results. It is quite probable that the wood from those that were not weighed lost weight during the interim between pruning and weighing, as the weights taken for the years 1912 and 1913 do not show the differences in weight between the halves of the section shown in 1911. Table VII should be studied with Table VIII which gives the average number of canes per acre put up on each plat for 1911, 1912, 1913 and 1914.

Table VII.— Comparative Weights of Pruned Wood per Acre From Grape Vines in Fertilizer Experiments.

Plat No.	Treatment	1911.	1912.	1913.	3-year average.
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
1	Complete fertilizer; lime......	*1,244	1,020	1,088	1,117
2	Complete fertilizer............	*1,387	1,196	1,292	1,291
3	Nitrogen and phosphorus......	*1,360	1,156	1,088	1,201
4	Nitrogen and potassium.......	*1,360	1,258	1,360	1,326
5	Phosphorus and potassium....	*1,224	1,033	816	1,024
6	Check......................	1,305	707	734	915
7	Complete fertilizer; lime......	1,734	1,162	1,496	1,464
8	Complete fertilizer...........	1,747	1,183	1,400	1,443
9	Nitrogen and phosphorus......	1,679	1,162	1,190	1,343
10	Nitrogen and potassium.......	1,720	1,203	1,407	1,476
11	Phosphorus and potassium....	1,489	1,006	952	1,149

* Weights taken in spring of 1912. All others in the fall of their respective years.

Table VIII.— Total Number of Fruiting Canes per Acre Left on Grape Vines in Fertilizer Experiment Plats.

Plat No.	Treatment.	1912.	1913.	1914.	3-year average.
1	Complete fertilizer; lime......	2,815.2	1,985.6	2,332.4	2,377.7
2	Complete fertilizer...........	3,033.6	2,373.2	2,366.4	2,591.0
3	Nitrogen and phosphorus.....	3,094.0	2,373.2	2,142.0	2,536.4
4	Nitrogen and potassium.......	3,039.6	2,407.2	2,454.8	2,633.8
5	Phosphorus and potassium....	3,019.2	2,121.6	2,033.2	2,391.3
6	Check......................	2,856.0	2,087.6	1,387.2	2,110.2
7	Complete fertilizer; lime......	2,856.0	2,400.4	2,386.8	2,547.7
8	Complete fertilizer...........	3,066.8	2,407.2	2,407.2	2,627.0
9	Nitrogen and phosphorus.....	3,289.6	2,366.4	2,244.0	2,633.3
10	Nitrogen and potassium.......	3,107.6	2,434.4	2,434.4	2,658.8
11	Phosphorus and potassium....	2,862.8	1,897.2	2,019.9	2,259.9

The amounts of wood pruned further emphasize the fact, stated before, that the west part of the vineyard, in which are located plats 1, 2 and 3, is somewhat weaker than the remainder of the section. Coming to the several plats we find that those on which the complete fertilizer and lime were used have pruned 375 pounds more wood per acre, during the three-year period, 1911, 1912 and 1913, than the check, while 352 more canes per acre were put up than in the check. From the complete fertilizer plats were pruned 452 pounds more wood per acre than in the check, yet 499 more canes were left. From the nitrogen and phosphorus plats were pruned 357 pounds more wood and 474 more canes were left. From the nitrogen and potassium plats were pruned 486 pounds more than the check and 535 canes more were put up, while from the phosphorus and potassium plats were pruned 121 pounds more wood per acre and 121 canes more than in the check were put up.

These data seem to signify that the fertilized plats are producing a larger annual wood growth than the unfertilized check, as well as bearing more fruit. Table IX gives the averages for 1911, 1912 and 1913 of the amounts of wood pruned per acre from each plat and the number of canes per acre put up during 1912, 1913 and 1914.

TABLE IX.— COMPARATIVE WOOD GROWTH OF GRAPE VINES IN FERTILIZER EXPERIMENTS.

Plat No.	Treatment.	Average amount of wood pruned per acre, 1911, 1912 and 1913.	Average number of canes put up per acre, 1912, 1913 and 1914.
		Lbs.	
1	Complete fertilizer; lime	1,117	2,377.7
2	Complete fertilizer	1,291	2,591.0
3	Nitrogen and phosphorus	1,201	2,536.4
4	Nitrogen and potassium	1,326	2,633.8
5	Phosphorus and potassium	1,024	2,391.3
6	Check	915	2,110.2
7	Complete fertilizer; lime	1,464	2,547.7
8	Complete fertilizer	1,443	2,627.0
9	Nitrogen and phosphorus	1,343	2,633.3
10	Nitrogen and potassium	1,476	2,658.8
11	Phosphorus and potassium	1,149	2,259.9

TABLE X.— FINANCIAL GAIN OR LOSS PER ACRE FROM USE OF FERTILIZERS ON GRAPES.

	Plat No.	1909.	1910.	1911.	1912.	1913.	Total.
Complete fertilizer; lime.	1	+$8 92	—$18 91	—$18 08	—$27 21	+$26 05	—$29 23
	7	+14 70	—6 17	—11 88	+19 69	+71 05	+87 39
Complete fertilizer.	2	+18 63	—11 91	—7 75	+4 17	+62 55	+65 69
	8	+15 88	—18 27	—9 98	+27 99	+57 05	+72 67
Nitrogen and phosphorus.	3	+34 65	—10 59	—5 99	—1 41	+38 05	+54 71
	9	+29 70	—15 14	—14 49	+29 70	+56 05	+85 82
Nitrogen and potassium.	4	+6 55	+5 51	—7 93	—0 86	+65 20	+68 47
	10	+21 40	—7 68	+0 27	+26 79	+76 20	+116 98
Phosphorus and potassium.	5	—7 52	—11 00	—2 50	+19 44	+20 85	+19 29
	11	+37 57	—16 91	—14 95	+14 54	+30 35	+50 60

Table X gives the net gain or loss in dollars and cents per acre for each fertilized plat as compared with the money return from the unfertilized check plat. The cost of the fertilizers that were applied to each plat has varied from year to year, as has the price obtained for the fruit. The amount deducted for the materials each year was based on the market values for that year. The returns from the sale of the fruit represent actual sales made.

CO-OPERATIVE EXPERIMENTS.

In 1910, vineyards were selected in several parts of the Chautauqua Belt for co-operative commercial fertilizer, stable manure and green manure tests. The vineyards selected represent distinct variations in soil types and differences in altitude. The owners and locations of the vineyards are as follows:

S. S. Grandin, Westfield, 5 acres, Dunkirk gravelly loam grading into clay loam.

Hon. C. M. Hamilton, State Line, 2 acres, Dunkirk clay loam.

James Lee, Brocton, 2¼ acres, Dunkirk shale loam.

H. G. Miner, Dunkirk, 2½ acres, Dunkirk clay loam.

Miss Frances Jennings, Silver Creek, 4⅔ acres, Dunkirk shale loam to clay loam.

J. T. Barnes, Prospect Sta., 5 acres, Dunkirk shale loam.

In 1911, the Jennings vineyard had to be given up. This is to be regretted as owing to uniformity of soil and evenness of the

stand of vines it promised much. All were vineyards of Concords. The previous fertilization, with but one or two exceptions, was rather infrequent applications of stable manure in moderate amounts. In the exceptions some commercial fertilizers had been used.

CARE OF THE VINEYARDS.

The cultivation before and during the period of the experiments was that ordinarily practiced; namely, spring plowing, harrowing, grape-hoeing and more or less frequent harrowings or cultivations with the spring-tooth and disc harrows and diamond-tooth cultivator until about August 1 and then plowing back to the vines. Only in two vineyards has spraying been consistently done. The vineyards, with but two exceptions, were considered old. These two are the Jennings and the Hamilton plantations which were, respectively, 5 and 7 years set at the beginning of the experiments.

Each vineyard has been pruned and trained according to the Chautauqua System, the work being done usually by a man engaged particularly for the task and not by the owner. There are two exceptions to this practice in the six vineyards.

AMOUNTS AND METHODS OF APPLICATION OF FERTILIZERS.

The same carriers and amounts of nitrogen, phosphorus and potassium have been used in each case that were used and discussed under the Station experiment, namely nitrate of soda, dried blood, acid phosphate and sulphate of potash. The only difference in the methods of application was that the materials were all applied in a single treatment and were plowed under. The time of application was generally a little later than for those made at Fredonia. The same forms of lime and like amounts were used in these experiments as in the Station vineyards. The stable manure was applied in the spring at the rate of 5 tons per acre and plowed under. The rate and time of seeding the green crops was approximately the same as in the other experiments.

GAUGING THE RESULTS.

In measuring the relative values of the different treatments in the cooperative vineyards, only fruit yields have been used. The range of time over which vineyards are pruned and lack of facilities

for weighing wood made impossible the taking of data on wood production. So, too, the interval that would elapse between the gathering of leaves and weighing was so great that such data would be valueless. All yields have been figured on the acre basis and as the greater number of the vineyards were set 8 x 8 feet, or 680 vines per acre, all have been computed for this number of plants for sake of uniformity. Only the actual number of vines in a plat have been considered in computing the average per vine. Thus, if a row originally contained 66 vines but 24 were missing, 42 vines alone have produced the fruit for that plat and the average was made from the 42.

JENNINGS VINEYARD.

The Jennings vineyard is located on a level piece of Dunkirk shale loam varying to Dunkirk clay loam. The part on the shale loam is fairly well drained naturally while the portion on the clay loam is decidedly wet. There is no artificial underdrainage. The vineyard is a young and promising one for this type of soil. The rows, if no vines were missing, would contain 66 vines. The actual number varies from 42 to 66. Each plat consists of a single row separated from the others by discard rows. The plats are duplicated. The rows extend in a general north and south direction. The fruit from the discard rows was not weighed. This vineyard was sprayed once each year during 1910 and 1911 for the control of grape root-worm and powdery mildew.

Table XI gives the treatment of the plats and their relative order in the vineyard together with the yields in tons per acre for the years that the experiment ran, and the two-year average.

Careful study of the data does not show striking consistent differences between the treated plats nor between those treated and untreated. A comparison of Plats 2, 3, 4 and 5 would seem to indicate that there was a slight gain from the use of nitrogen, but in no case is it sufficient to pay for the fertilizer. Again comparing Plats 12, 13 and 14 it would seem that there has been some gain from the use of stable manure, but even here the increase is not enough to buy the manure and apply it.

TABLE XI.— YIELD OF GRAPES ON PLATS DIFFERENTLY FERTILIZED IN JENNINGS VINEYARD.

Calculated to tons per acre.

Plat No.	Treatment.	1910.	1911.	Average.
		Tons.	*Tons.*	*Tons.*
1	Complete fertilizer; lime	2.38	2.82	2.60
2	Complete fertilizer	2.72	3.87	3.29
3	Check	2.44	3.29	2.86
4	Nitrogen and phosphorus	2.51	3.67	3.09
5	Nitrogen and potassium	2.48	3.91	3.19
6	Phosphorus and potassium	1.76	3.63	2.69
7	Complete fertilizer; lime	1.80	3.12	2.46
8	Complete fertilizer	1.63	3.43	2.53
9	Nitrogen and phosphorus	1.97	3.40	2.68
10	Nitrogen and potassium	1.56	3.67	2.61
11	Phosphorus and potassium	2.38	2.92	2.65
12	Check	2.10	3.46	2.78
13	Stable manure	2.38	3.77	3.07
14	Stable manure; lime	2.44	4.35	3.39
15	Mammoth clover	2.38	3.26	2.82
16	Check	2.07	4.14	3.10
17	Mammoth clover; lime	2.21	3.60	2.90
18	Barley and cowhorn turnips	2.34	3.43	2.88
19	Barley and cowhorn turnips; lime	2.27	2.44	2.35
20	Stable manure	2.17	3.84	3.00
21	Stable manure; lime	3.23	3.36	3.29
22	Mammoth clover	2.00	3.36	2.68
23	Check	2.44	3.06	2.75
24	Mammoth clover; lime	1.42	2.72	2.07
25	Barley and cowhorn turnips	2.78	3.23	3.00
26	Barley and cowhorn turnips; lime	1.97	3.19	2.58

A study of the average yields from Plats 15, 16, 17 and 18 leads to the conclusion that no benefit thus far had occurred from the use of green manures. Comparing Plats 20, 21, 22, 23, and 24 we again note slight gains from the stable manures but still insufficient to pay for the applications, while the green manures show yields less than the check. Applications of lime with stable manure present consistent gains in each set of plats and sufficient to pay for the treatment, while the applications made on the green manure plats do not indicate any gain. The low production of 1910 and its contributory causes have been discussed earlier in this bulletin. The fact stands out with this vineyard as with the Station vineyard

that the yields for this year were very uniform over all the plats including the checks and that this tended to equalize the yields of 1911.

MINER VINEYARD.

The Miner vineyard is situated on a level piece of low-lying land of the Dunkirk clay type, which is as a rule much improved by underdrainage. The rows run in a general north and south direction and vary in length from 40 to 59 vines. Each plat consists of a single row separated from the others by discard rows. During the period over which this experiment has run, the vineyard has not been sprayed. Severe infestations of the grape root-worm and the grape leaf-hopper occurred in 1911 and 1912 respectively. Just how much these insects have lessened the yields cannot be determined, but judging from the appearance of the vines it was considerable. Table XII gives the order in which the plats occur in the vineyard, the annual yields per acre for each plat and the four-year average.

Table XII.— Yield of Grapes on Plats Differently Fertilized in Miner Vineyard.

Calculated to tons per acre.

Plat No.	Treatment.	1910.	1911.	1912.	1913.	4-year average.
		Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1	Complete fertilizer; lime	0.81	3.63	2.23	0.91	1.89
2	Complete fertilizer	0.68	2.73	2.26	1.12	1.69
3	Check	0.74	2.65	2.89	0.98	1.81
4	Nitrogen and phosphorus	1.02	3.11	2.34	1.12	1.89
5	Nitrogen and potassium	1.15	3.63	2.44	1.02	2.06
6	Check	0.74	2.64	2.38	0.81	1.64
7	Phosphorus and potassium	0.85	2.84	2.34	0.95	1.74
8	Stable manure	0.68	2.98	2.82	1.56	2.01
9	Check	0.85	2.76	1.87	1.08	1.64
10	Stable manure; lime	0.78	2.97	2.51	1.63	1.97
11	Mammoth clover	0.78	2.69	2.41	1.12	1.75
12	Mammoth clover; lime	1.19	2.19	2.44	1.05	1.71
13	Check	1.02	2.34	2.00	0.74	1.52
14	Wheat and cowhorn turnips	0.81	2.30	1.80	0.64	1.38
15	Wheat and cowhorn turnips; lime	1.02	3.57	1.93	0.57	1.77

These data in no way indicate superiority of one treatment over another nor of that of any application over the checks. They only

serve to emphasize the influence of a previous crop upon succeeding ones, a point that has been mentioned before. This is shown by comparing the yields of 1911 with those of 1912 and 1913. The extreme high-yielding plats of that year fell off more proportionally in the years 1912 and 1913 than those that yielded moderately the previous year, while with two plats there was a gain in 1912.

LEE VINEYARD.

The Lee vineyard is a typical upland vineyard situated on the hillside south and east of Brocton. The soil is of the Dunkirk shale loam type and quite stony. The natural drainage is better than in many vineyards, owing in part to the slope, yet rock pockets keep parts of the land wet. However, lack of drainage is not so important here as in hundreds of other cases. The rows extend in a general east and west direction at right angles to the slope, varying in length from 40 to 52 vines. The plats consist of single rows separated by discards. The vineyard has had no serious insect infestations during the life of the experiment and consequently has not been sprayed. Table XIII represents the order of the plats in the experiment with their yields in tons per acre for each year and the four-year average.

TABLE XIII.— YIELD OF GRAPES ON PLATS DIFFERENTLY FERTILIZED IN LEE VINEYARD.
Calculated to tons per acre.

Plat No.	Treatment.	1910.	1911.	1912.	1913.	4-year average.
		Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1	Wheat and cowhorn turnips; lime	1.25	2.04	2.93	0.74	1.74
2	Check	1.25	2.09	2.48	0.63	1.61
3	Wheat and cowhorn turnips	1.05	2.00	2.25	0.85	1.53
4	Mammoth clover; lime	1.42	1.79	2.52	0.81	1.63
5	Mammoth clover	1.17	1.83	1.99	0.74	1.43
6	Stable manure; lime	1.36	2.14	3.40	0.98	1.97
7	Stable manure	1.56	2.17	2.84	1.08	1.91
8	Check	1.29	2.24	2.20	0.61	1.58
9	Phosphorus and potassium	1.39	2.09	2.43	0.68	1.64
10	Nitrogen and potassium	1.22	1.87	2.46	0.61	1.54
11	Nitrogen and phosphorus	1.46	2.19	2.57	0.68	1.72
12	Complete fertilizer	0.98	1.73	2.50	0.61	1.45
13	Complete fertilizer; lime	1.12	1.66	2.04	0.88	1.42

There appears from a consideration of the four-year average a slight gain from the use of stable manure but this is not great enough to pay for the manure applied. Plats 12 and 13 have always been inferior rows according to information furnished by the owner. Our subsequent observations and these data seem to confirm it.

BARNES VINEYARD.

The Barnes vineyard at Prospect Station is another upland vineyard situated on Dunkirk shale loam. It differs from the Lee vineyard in that it lies very level below a high ridge from which much seepage water gains access to it. It would be benefited by underdrainage. The rows extend in a general east and west direction and consist of 31 vines each. The plats comprise from four to six rows. Infestations of the grape root-worm shortly before the beginning of this experiment, coupled with the wetness of the soil, have tended to keep this vineyard at low production. Table XIV gives the yields in tons per acre for each plat for the four years and the average. The order in which the plats are placed is different from that in the foregoing vineyards for the reason that the experiment was planned originally for a renovation experiment by the use of fertilizers and spraying. This accounts for the checks being located in pairs.

Analyses of the returns indicate that previous to 1912 none of the treatments returned sufficiently increased yields over the checks to make the application profitable. The stable manure Plats 1, 2, 13 and 14 returned a profit over the checks in 1912 and 1913, while the stable manure Plats 7 and 8 did not. In 1912 the complete fertilizer applications in no instance returned a profit, nor did the phosphorus-potassium-lime-cover-crop plats. The complete fertilizer Plats 3 and 16 yielded enough above the checks in 1913 to pay small returns while Plat 9 failed to do so. Phosphorus-potassium-cover-crop and lime Plat 4 gave net gains over check. Plat 5 and Plat 10 likewise gave small returns over Plat 11 but did not over Plat 12, both checks. Plat 17 returned a net gain over one check plat, 15, but failed to give a sufficient increase to return a profit over the other check plat, 18. These variations can only be accounted for on the ground of non-uniform fertilization in previous years coupled with soil differences which have not become apparent.

TABLE XIV — YIELD OF GRAPES ON PLATS DIFFERENTLY FERTILIZED IN BARNES VINEYARD
Calculated to tons per acre.

Plat No.	Treatment.	1910.	1911.	1912.	1913.	4-year average.
		Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1	Stable manure	1.12	2.14	2.55	1.15	1.74
2	Stable manure; lime	1.12	2.38	2.72	1.08	1.82
3	Complete fertilizer	1.02	2.38	1.97	1.25	1.65
4	Phosphorus and potassium; lime	0.91	1.87	2.38	1.05	1.55
5	Check	1.29	1.93	1.80	0.81	1.45
6	Check	0.98	2.00	1.42	0.35	1.18
7	Stable manure	0.88	2.10	1.94	0.71	1.43
8	Stable manure; lime	1.19	2.17	1.90	0.70	1.49
9	Complete fertilizer	0.71	2.51	1.66	0.78	1.41
10	Phosphorus and potassium; lime	0.78	2.14	1.53	0.78	1.30
11	Check	1.08	2.17	1.59	0.47	1.32
12	Check	0.44	2.07	2.07	0.95	1.38
13	Stable manure	0.61	2.14	2.82	1.22	1.72
14	Stable manure; lime	0.74	2.14	2.75	1.63	1.81
15	Check	0.57	2.12	2.10	0.64	1.35
16	Complete fertilizer	0.74	2.38	2.78	1.25	1.78
17	Phosphorus and potassium; lime	1.05	2.17	2.65	1.22	1.77
18	Check	1.36	2.24	2.44	0.91	1.73

GRANDIN VINEYARD.

The Grandin vineyard at Westfield, located in part on Dunkirk gravelly loam and the remainder on Dunkirk clay loam, presents a well drained area succeeded by a wet one. While each plat extends on each type of soil, the plats are not equally situated over the two. Approximately two-thirds of the length of the rows is on the Dunkirk clay loam while but one-third is on the gravelly loam. On the west side of the vineyard a still greater proportion of the row is on clay loam. The length of the plats varies from 129 vines on the west side of the section to 99 vines on the east, equal in area to about one-fifth of an acre. The rows run in a north and south direction. Spraying in this vineyard has been consistent and thorough. Commercial fertilizers and stable manures had been used previous to the beginning of the experiment by the owner in an experimental way but no records of the behavior of the vines under different treatments were available. Each plat row is separated from the others by discard rows.

Table XV.— Yield of Grapes on Plats Differently Fertilized in Grandin Vineyard.
Calculated to tons per acre.

Plat No.	Treatment.	1910.	1911.	1912.	1913.	4-year average.
		Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1	Phosphorus and potassium....	2.44	2.95	2.34	1.25	2.24
2	Nitrogen and potassium......	2.27	2.82	2.18	1.03	2.07
3	Nitrogen and phosphorus.....	2.41	2.82	2.32	1.02	2.12
4	Check......................	2.41	2.65	2.23	1.02	2.07
5	Complete fertilizer...........	2.44	2.58	2.42	1.19	2.15
6	Complete fertilizer; lime......	2.61	2.93	2.75	1.19	2.37
7	Wheat and cowhorn turnips; lime....................	2.10	2.48	2.66	1.22	2.11
8	Wheat and cowhorn turnips ..	2.75	2.75	3.06	0.98	2.38
9	Mammoth clover; lime.......	2.75	2.92	2.75	1.42	2.46
10	Check......................	2.99	2.44	2.92	0.85	2.30
11	Mammoth clover............	1.15	2.44	2.86	1.19	1.91
12	Stable manure; lime..........	2.34	2.78	3.53	1.83	2.62
13	Stable manure...............	2.07	2.44	3.58	1.63	2.43

Table XV gives the yields in tons per acre for each plat during the four years that the test has run, with the four-year average. A study of the table shows that for the years 1910 and 1911 none of the treatments have brought about yields greater than the unfertilized check. In 1912, however, the increased returns from the stable manure plats, 12 and 13, returned a profit over the check plat, 10. Further than this no consistent increase can be noted. No gains are apparent from the use of commercial fertilizers in 1913. There is evidently a gain from the use of clover as a green manure and again the use of stable manure has proved profitable. Lime used in conjunction with the clover and the stable manure has contributed profitably to greater yields. The apparent gain from its use in Plat 7 as compared with Plat 8 is offset when we compare the yields of the two in 1912 and note how the 1913 yield has been influenced by each. Plat 8 which produced .40 of a ton more than Plat 7 in 1912 yielded .34 of a ton less in 1913.

HAMILTON VINEYARD.

The Hamilton vineyard, located at State Line and consisting of two acres, is situated on Dunkirk clay loam. This vineyard is

wet. Much seepage water from the hills above rises to the surface over it. The west part is worse in this respect than the east portion. The vines, while they have been planted 7 or 8 years, have the appearance of vines set only 3 or 4. During an extremely dry season fair wood growth is made but in a wet one it is very limited, with a correspondingly short crop. This vineyard has not been sprayed during the time the experiment has run. The plats consist of two rows, each of which runs in a north and south direction. Each row contains 44 vines. Thus each plat comprises about .14 of an acre. The stable manure and lime, clover and lime and the barley-turnips and lime plats were limed a year previous to the beginning of the test. No commercial fertilizers nor stable manure had been applied for two or three years previous to 1910. Table XVI gives the order in which the plats occur in the vineyard with the yields in tons per acre for each year and the four-year average.

TABLE XVI.— YIELD OF GRAPES ON PLATS DIFFERENTLY FERTILIZED IN HAMILTON VINEYARD

Calculated to tons per acre.

Plat No.	Treatment.	1910.	1911.	1912.	1913.	4-year average.
		Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1	Check	1.19	2.07	2.09	1.02	1.59
2	Phosphorus and potassium	0.95	2.72	2.83	1.93	2.10
3	Nitrogen and potassium	0.78	3.60	2.15	0.98	1.87
4	Check	1.66	2.40	1.75	0.61	1.60
5	Nitrogen and phosphorus	0.88	2.27	2.01	0.71	1.46
6	Complete fertilizer	1.12	2.55	2.24	1.15	1.76
7	Complete fertilizer; lime	0.85	2.44	1.76	0.85	1.47
8	Stable manure	0.68	2.31	2.02	0.71	1.43
9	Wheat and cowhorn turnips	1.29	2.14	2.42	0.44	1.57
10	Mammoth clover	0.71	1.93	1.30	0.30	1.06
11	Check	0.81	2.07	1.55	0.51	1.23
12	Wheat and cowhorn turnips; lime	0.78	1.97	1.66	0.40	1.20
13	Mammoth clover; lime	0.85	2.39	1.43	0.37	1.26
14	Stable manure; lime	0.54	2.38	1.91	1.08	1.47

Consideration of the data discloses nothing that would indicate any material gain for the season of 1910. In 1911, however, two plats, one the nitrogen-potassium and the other the phosphorus-

potassium, returned crops that gave a net profit over the checks. This gain may be due to the larger yield of the check plats the year before rather than a direct effect of the fertilizers. That the phosphorus-potassium plat was at the beginning superior to the others is further shown by a reference to the yields of 1912 and 1913. The stable manure plat and the wheat and cowhorn turnip plat each yielded crops at a profit over the check in 1912. Again we must conclude, in case of the wheat-turnip plat at least, that the treatment was not the determining factor, but rather some unknown influence, as for example soil variation, previous fertilization or the pruning. In 1913, only the stable manure-lime plat yielded a net profit above the check plat, 11. The superiority of the phosphorus-potassium plat has already been explained. The four-year averages do not present any data that would warrant definite conclusions as to the superiority of any one treatment over another.

SUMMARY OF RESULTS.

In the experiments at Fredonia, nitrogenous fertilizers have had a marked effect upon wood growth and yield and quality of fruit. The first season, 1909, the fertilizers containing nitrogen apparently increased the crop of that year, although plat variations might account for the greater yield of the fertilized over the unfertilized vines.

Bud injury during the winter of 1909 and 1910 reduced the crop the second year 50 per ct. The fertilized and unfertilized plats were affected in like degree. The crop of 1910 was fairly uniform on all the plats. The general light crop, no doubt, tended to equalize the yields for the succeeding year, 1911.

No differences in the amount or the color of the foliage were apparent until the summer of 1912 in which season the foliage in the nitrogen-fertilized plats clearly showed superiority over that from the plats on which no nitrogen had been applied. The foliage from the phosphorus-potassium plats was somewhat superior to that from the check plat.

Nitrogen and potassium have in some degree increased the size of the leaves as shown in Table VI. They have also materially increased the amount of wood growth. Table VII, a comparison of the plats, indicates that nitrogen was the more important of the two elements in bringing about these increases in wood growth.

The plats receiving the nitrogenous application produced fruit in the years 1912 and 1913 somewhat superior, in size of cluster, size of berry and compactness, to that from the plats to which phosphorus and potassium had been applied and considerably superior to that from the check. The phosphorus-potassium plats yielded fruit better than the check in these respects and probably more mature at the time the observations were made. The nitrogen has probably indirectly affected fruit characters through its action in producing more vigorous wood and foliage.

It appears that nitrogen is the limiting factor in this vineyard. Appreciable results were not obtained, however, until after several applications of the fertilizer had been made.

Lime seems not to have influenced the vines in the least while phosphorus and potassium, as applied in the fertilizers used, have not greatly influenced the vines for the better — have not proved profitable fertilizers.

The data in the cooperative work with commercial fertilizers, stable manure and green manures are confusing and unsatisfactory. Unsatisfactory because of the great variability of the results from the treatments in any one vineyard or in the several vineyards compared with one another. Taken as a whole they do not corroborate the work in the Station vineyard at Fredonia.

SUGGESTIONS FROM THE RESULTS.

The results of the several tests of which this bulletin is an account throw comparatively little light on the value of fertilizers for grapes. It is evident that the fertilization of vineyards, as well as of orchards, fields and gardens, is so involved with other factors that only carefully planned and long continued work will give reliable results. Indeed, field experiments even in carefully selected vineyards, as the cooperative experiments show, may be so contradictory and misleading as to be worse than useless if deductions are made from the results of a few seasons. The work that has been done is not without value, however, for it has brought forth information about fertilizing vineyards that ought to be most helpful to grape-growers. Thus the results suggest:

First, and most important, that it is usually waste, pure and simple, to make applications of fertilizers in poorly-drained vineyards, in such as suffer frequently from winter cold or spring frosts,

where insect pests are epidemic and uncontrolled, or where good care is lacking. The experiments furnish several examples of inertness, ineffectiveness, or failure to produce profit where the fertilizers were applied under any of the conditions named.

Second, it is certain in some of the experiments and strongly indicated in others that the soil is having a one-sided wear — that only one or a very few of the elements of fertility are lacking. The element most frequently lacking is nitrogen. The grape-grower should try to discover which of the fertilizing elements his soil lacks and not waste by using elements not needed.

Third, the marked unevenness of the soil in all of the seven vineyards in which these experiments were carried on, as indicated by the crops and the effects of the fertilizers, furnishes food for thought to grape-growers. Maximum profits cannot be approached in vineyards in which the soil is as uneven as in these, which were in every case selected because there was an appearance of uniformity. A problem before the grape-growers of Chautauqua County is to make more uniform all conditions in their vineyards.

Fourth, a grape-grower may assume that his vines do not need fertilizers if they are vigorous and making a fair annual growth. When the vineyard is found to be failing in vigor, the first step to be taken is to make sure that the drainage is good; the second step, to control insect and fungus pests; the third, to give tillage and good care; and the fourth step is to apply fertilizers if they be found necessary.

NEW OR NOTEWORTHY FRUITS. II.*

U. P. HEDRICK.

INTRODUCTION.

The purchase of new fruits is one of the perennial problems of fruit-growers. Each spring the catalogues come and the tree-buyer must decide whether he will test the most promising of the new varieties offered or wait until their value is demonstrated by others. The problem is made doubly difficult because nurserymen customarily describe the merits of their novelties in glowing terms and brightly colored plates but do not trouble themselves to illuminate by word or picture the faults of their introductions. Absolute confidence in these one-sided descriptions is usually a source of disappointment; and the buyer, once defrauded, assumes a hostile attitude toward all new varieties. Condemnation of novelties has thus become habitual among fruit-growers. Such an attitude is unsound. A brief consideration of the improvement of plants shows that denouncing novelties is setting oneself against progress.

Unquestionably the limit of improvement has not been reached in the domestication of any cultivated fruit. Seedling fruits spring up everywhere, the best of which survive and compete with established sorts. Through intercrossing, plant-breeders are constantly producing new varieties of all the fruits. So, too, we occasionally find sports or mutations more valuable than the variety from which they are offshoots. Again, every now and then a species not known in cultivation is ushered in and proves profitable. Evidence of the advancement of horticulture through the introduction of new forms is to be found in the many recent new-comers manifestly in advance of any of their kind. Evolutionists tell us that there are more species of plants on earth now than there have ever been at any previous time. We may assume that if multiplication of forms accompanies the evolution of wild life the evolution of cultivated plants must follow the same law.

* Reprint of Bulletin No. 385, April.

There are two ways in which the fruit-grower can in a measure meet the problem of horticultural novelties. He can rely upon the trustworthiness of the nurseryman and permit him, as the introducer, to be his guide; or, he can await the results of tests made by others — especially of tests made at the various experiment stations.

The present bulletin is written to be helpful in either case. There are fruit-growers, prudent ones, too, who, even though now and then deceived, take great pleasure in growing new introductions. To such experimenters this bulletin offers suggestions to guide them in determining what new fruits to look upon as promising and what ones to distrust, it being quite out of the question for any one man, unless he has unlimited time and means, to try all. To those who have not the means or the time, we give descriptions of a number of new fruits which have been thoroughly tested and have been found valuable on the grounds of this Station.

SUGGESTIONS TO BUYERS OF FRUITS.

The term "improved" added to the name of an old variety is a misrepresentation, pure and simple. Out of the score or more of fruits tested at this Station sent out as "improved," not one has differed in any way from the original variety. Fruits propagated from cuttings or grafts remain substantially the same indefinitely.

The term "pedigree" is used by some nurserymen in a slightly different sense than "improved" but still with the inference that "pedigreed" varieties are in some way improved. Buyers of "pedigreed" stock should demand proof of the supposed superiority. Varieties of fruit are pure-bred in the most literal sense, their line of descent, barring a very occasional break, being absolutely unchangeable.

Occasionally, as we have just said, there are breaks or bud variations in fruits. When it is proved that a variation is transmitted through budding or grafting, the new strain, possibly divergent enough to be a variety, may be of value. In the study of the history of several thousand varieties of fruits at this Station it does not appear that many sorts, not one out of a thousand, have originated as bud-variations.

Many varieties of fruits come nearly true to seed. There are several undesignated strains of some well-known plums, peaches and cherries, which have originated as seedlings and each of which has

particular value or is unique enough to be given a name, just as the many seedlings of the McIntosh, Ben Davis, Winesap and other apples are separately denominated.

A variety is not sufficiently well described to make it worth buying unless the merits and faults of the plant as well as of the product are depicted. In particular, the adaptabilities of a variety to soils and climates and its immunities to insects and fungi should be known before it is largely planted.

One should look with suspicion on varieties which are advertised as surpassing their kind in all respects. Most novelties, even the most worthy, are superior in but one or a few respects; as, in prolonging the season, in improvement of quality, in meeting some new climatic condition, in adaptability for some particular use, or, and most frequently, because of greater productiveness.

Varieties of worth may be more commonly expected in fruits domesticated but a short time, and therefore little improved, than in species long under cultivation and much improved; thus, American species of grapes give more new varieties than the Old World species, American plums are more variable than those of Europe, American raspberries, blackberries and strawberries are prolific of new sorts; the apple, quince, pear, cherry and peach, all old types, are relatively stable.

Old varieties are often reintroduced as novelties because of a variation of the type brought about by local influences; thus, the Green Newtown of the Hudson, the Yellow Newtown of Hood River, the Albemarle Pippin of Virginia, and the Five-Crowned Pippin of Australia, differ in all these regions; but brought together in any one place, all are the same.

It is best, if possible, to buy new fruits from the originator or introducer as these men are most likely to have the variety true to name, and, moreover, most deserve to reap the reward for bringing forth the novelty.

FRUITS TESTED BY THE NEW YORK AGRICULTURAL EXPERIMENT STATION.

This Station makes an effort to test every new fruit offered by American nurserymen which seems at all suited to the soil and climate of New York. Beginning in 1913, with Bulletin No. 364, we are undertaking to describe annually the best recent fruit introductions as they grow at Geneva. We are also undertaking to call

attention to noteworthy sorts, which, though old, have not received, for one reason or another, the attention they deserve from fruit-growers. Neither trees nor cions of these new or noteworthy fruits can be obtained from this Station.

APPLE.

King David.— This apple is supposed to be a cross between Jonathan and Arkansas Black and has proved superior to either parent in several characteristics. The trees are hardy and productive and quite up to the average in vigor and health. The apples are larger than the Jonathan and even better colored, making King David one of the beauties of the orchard, for, added to the deep, solid, red color, are rotundity in shape and uniformity in size, the three qualities giving the variety almost perfection from an aesthetic standpoint. The fruit hangs long and well on the tree, all the while deepening in color, but for late keeping should be picked as soon as well overspread with red and before the seeds are well ripened. The flesh is firm, fine, crisp, tender, spicy and juicy, and of best quality. Its chief fault appears to be a slight tendency to decay at the core, especially when overripe. The high quality and the remarkable attractiveness of King David make it one of the most promising new apples.

King David was found growing in a fence row in Washington county, Arkansas, in 1893, and the following year was transplanted to a permanent orchard where it came to the attention of Stark Brothers Nursery Company, Louisiana, Missouri, in 1902. It was introduced to commerce by the Starks a year or two after its fortunate discovery.

Tree vigorous, healthy, hardy, productive; branches long, moderately stout. Fruit of medium size, roundish-oblate to oblate-conic, slightly ribbed; stem medium in length, slender; cavity moderately deep and broad, usually russeted; calyx small, closed; basin medium in depth, somewhat abrupt, furrowed; skin thin, tender, smooth; color pale greenish-yellow, almost entirely overspread with a very attractive deep, dark red, changing to scarlet; flesh distinctly yellow, firm, crisp, moderately tender, juicy, brisk subacid, spicy and aromatic, good to very good; season November to February.

PEACH.

Edgemont.— In fruit and tree, the Edgemont is much like the well-known Late Crawford but surpasses that peach in several

important characters. In fact, of the score or more of peaches of the Crawford type, in many respects the best of the several types of peaches, Edgemont is distinctly superior to all on our grounds. It is a few days or a week earlier than Elberta, is juicier, less fibrous, much excels that variety in quality and, though the individual peaches are not quite as large in size, yet at Geneva the yield of fruit is even greater. If the Edgemont proves adapted to as wide a range of climates and soils as the Elberta, we shall have a new commercial peach of very great value. Whether it succeeds in commerce or not, Edgemont is well worth planting in home orchards by virtue of its exceptionally high quality and alluring appearance.

The Edgemont, shortened from Edgemont Beauty, in accordance with the rules of the American Pomological Society, is of rather recent origin, having been introduced by the Miller Orchard Company of Edgemont, Maryland, in 1902.

Tree very large, upright-spreading, somewhat open, productive; leaves large, oval, lanceolate; upper surface smooth, dark green; lower surface silvery green; season of bloom with Elberta, short. Fruit midseason, season short; large, roundish-oval to somewhat conic, halves unequal; cavity medium to deep, rather wide, slightly flaring; suture shallow, deepening toward the apex; apex roundish to bluntly pointed; color greenish-yellow changing to a pale lemon-yellow, splashed with dull red with a carmine blush; overspread with short pubescence; dots numerous, rather conspicuous; skin thin, tough, adherent; flesh yellow, faintly red at the pit, fine, tender, slightly fibrous, rich, sweet, spicy; very good; stone free.

CHERRY.

Abbesse d'Oignies has so many good characters that it is well worth trying commercially wherever cherries are grown in the United States. Curiously enough, it seems so far to have been tried only in the Middle West, Professor Budd having introduced it in Iowa from Russia in 1883. It grew in the Mississippi Valley, if we may judge from the accounts of it, as well as any cherry of its class in the unfavorable soil and climatic conditions of that region. We do not know of its having been tried elsewhere in the East than on our grounds and here we find it, in competition with practically all of the varieties of its class, one of the best of the Dukes. The trees are vigorous, hardy, fruitful. The cherries are large, dark red, of most excellent quality, combining the flavor of the Dukes with a firmer and yet tenderer flesh than the Montmorency. The

KING DAVID

EDGEMONT

ABBESSE D'OIGNIES

FRENCH

high quality and handsome appearance of the fruit, combined with the good character of the tree, ought to make Abbesse d'Oignies a very good commercial variety.

This cherry probably originated in western Europe about the middle of the 19th century. It is now a greater or less favorite wherever cherries are grown in the Old World, Professor Budd having found it, as we have said, in 1883, in Russia.

Tree large, vigorous, upright-spreading, hardy, productive; branches smooth, thick, somewhat drooping. Fruit matures late, ripening period long; large, roundish-oblate, slightly compressed; cavity of medium depth, wide, regular; suture a line; apex roundish, slightly depressed; color dark, attractive red; dots numerous, small, light russet, conspicuous; stem slender, one and five-eighths inches long, adhering to the fruit; skin moderately thick, rather tough, not adherent; flesh yellowish-white, with colorless juice, slightly stringy, tender, moderately soft, sprightly subacid; of very good quality; stone free, about three-eighths inch in diameter, roundish, turgid, slightly pointed, surface nearly smooth.

PLUM.

French.— Damson plums year by year increase in popularity in New York. Plantations are small but they are becoming more and more common and those who have them find them profitable. The trees, as all fruit-growers know, are not equalled by any other of the several groups of plums in vigor, hardiness and productiveness. Shropshire is the most commonly grown Damson, but we believe French to be a better variety and think that if planted more generally the Damson industry would be even more profitable and make a still greater growth. French is the largest of the Damsons — probably a hybrid between Shropshire and some Domestica plum. The trees are larger and more productive than those of other Damsons. The fruit is excellent in quality, handsome in appearance, of large size and may be eaten out of hand with relish when fully ripe or after a light frost — a point worth remembering where only Damsons can be grown. In some seasons the stone clings and in others, curiously enough, it is free. The trees are hardy, very fruitful and carry their foliage and fruit well. The season is a week or two later than that of the Shropshire, which is an advantage.

The origin of French is unknown, but it is probably an introduction from France and an old variety renamed. To the late S. D. Willard of Geneva, New York, to whom plum-growers are

indebted for several foreign varieties, we owe the introduction of French to America.

Tree large, vigorous, spreading, dense-topped, hardy, productive; branches numerous, with many fruit-spurs; leaves folded upward, long, oval; blooming season intermediate in time and length; flowers appearing after the leaves, one and one-fourth inches across, white, borne on lateral spurs, usually in pairs. Fruit late; large for a Damson, ovate, halves equal, suture a line; color dull black, overspread with thick bloom; stem slender, three-fourths inch long, adhering well to the fruit; skin thin, tough, separating readily; flesh greenish, juicy, fibrous, tender, sweet, pleasant and sprightly; good to very good; stone clinging, semi-clinging or free.

GRAPE.

Hicks.— In "The Grapes of New York" we took occasion to call attention to the merit of the Hicks grape as a competitor of the Concord. A few growers have since planted it but the variety does not begin to receive the attention it merits in New York. The fruit is almost identical with the Concord but ripens a little earlier — a fact which in itself should give the grape a place in the viticulture of this State. The chief merit of Hicks as compared with the Concord is, on our grounds and wherever we have heard of it in the State, that the vines are of stronger growth and are more productive. It is not improbable that Hicks would uniformly give greater yields in the Concord grape regions of this State than the Concord itself. It must be remembered, however, that ours is a heavy soil and that the Hicks might not surpass the Concord on lighter soils. Certain it is that Hicks is the better grape on heavy soils and, moreover, because of earlier ripening can be better grown where shortness of season is a consideration.

Hicks was introduced in 1898 by Henry Wallace, Wallston, Missouri, who states that it is a seedling sent from California, about 1870, to a nurseryman of St. Louis county, Missouri, passing eventually into the hands of Wallace, who named it Hicks. Both fruit and vine characters lead to the supposition that it is an offspring of Concord.

Vine vigorous to very vigorous, hardy, very productive; canes medium to long, numerous, of average thickness, dark brown to reddish-brown, surface covered with thin, blue bloom; leaves large, thin; upper surface dark green and glossy; lower surface whitish, becoming bronze, strongly pubescent; flowers fertile or nearly so. Fruit ripens a little earlier than Concord, ships and keeps as well as Concord; clusters large to medium, broad, tapering, often single-shouldered, compact; berries large, roundish,

dark purplish-black, covered with heavy bloom, inclined to shatter when over-ripe, firm; flesh greenish, juicy, faintly foxy, sweet at the skin but acid at the center; good in quality; seeds adhere somewhat to the pulp, of medium size.

GOOSEBERRY.

Chautauqua is not a new variety and it is surprising that growers have not more generally planted it. None of the American gooseberries can compete with Chautauqua and for a number of years the variety has held its own against the only other commonly grown European sort, Industry. Whether the Chautauqua is a pure-bred European gooseberry or not, the fact remains that mildew, the greatest enemy of the Old World varieties, affects it but little. The bush has the habit of the European varieties and in its stocky, compact, upright growth and thick, dark, shining, healthy leaves, surpasses many of the best of the Europeans. At first on the grounds of this Station Chautauqua was lacking in fruitfulness, but for some years past there have been abundant harvests; in 1913, for example, the variety yielded at the rate of 14,665 pounds per acre with plants set six by five feet apart. The fruit is usually of full size and ready for picking the first or second week of July. It is not safe to delay the harvesting of the fruit because of danger of sunscald — although this variety is no more subject to such injury than other varieties. A gooseberry sold under the name Columbus appears to be identical with Chautauqua. There are a few other European sorts which closely resemble the Chautauqua, as Freedom, Wellington Glory and Portage.

The origin of Chautauqua is not known. Plants were received at this Station in 1888 from the Lewis Roesch Company, Fredonia, New York, with the following account: "About 1876, Mr. Lewis Roesch, Fredonia, New York, first observed the plants growing in an old garden in Dunkirk, New York, and was so pleased with them that he secured permission to layer some of the plants for purposes of propagation. The plants were strong growers, great bearers of very large fruit of good quality and did not then mildew although mildew appeared later. Mr. Roesch was unable to learn the name of the variety. The party of whom he secured the stock did not know the variety, having secured it of a neighbor who had obtained it of some nurseryman. Chas. Downing saw the fruit and was of the opinion that it was some English variety or a seedling of one.

The variety was named and introduced in the spring of 1894 by Lewis Roesch, Fredonia, N. Y."

Plants medium to large, vigorous, stocky, upright-spreading, rather dense, very productive, with but little mildew; suckers few, smooth, straight, rather long, with short internodes, dull, light gray; two-year wood thick, roughened by dull gray scarf-skin over dark brownish-red; spines thick, strong, numerous, long, very sharp, in ones, twos and threes, attached at the base of the leaf; leaf-buds small, narrow, long, conical; leaves obovate to cordate, somewhat taper-pointed, rather thick; upper surface glossy, attractive green, smooth, glabrous; lower surface olive-green; margin blunt-crenate; petiole about three-fourths inch long, slender, pubescent and slightly hairy at the base; flowers open the last of May or early in June. Fruit matures the first half of July; large, one and one-eighth by one inch in size, mostly singly, roundish-oval to roundish, attractive silvery green; pedicels three-eighths inch long, pubescent; skin smooth, covered with bloom, thick, tough, translucent; flesh pale green, medium juicy, firm, sweet except near the skin; good in quality when fully mature; seeds large, numerous.

CURRANT.

Chautauqua, shortened in accordance with the rules of the American Pomological Society from Chautauqua Climbing, is one of the best of all in the currant collection of nearly forty varieties on the Station grounds. The plants are healthy and all that could be desired in vigor and productiveness, yielding in 1913 at the rate of 10,018 pounds per acre with plants set six by five feet. It ripens in midseason, with Fay or a few days later. The clusters are unusually long, with stems free from berries at the base and therefore easy to pick. The berries, while not uniformly as large as those of Fay, are of good size, handsome light red in color, high in quality and hang well even after ripening. Although the shipping quality has not been tested, Chautauqua will doubtless carry well over long distances.

This currant is a chance seedling found in the woods by Mr. R. F. Lonnen, Mayville, New York, about 1893 and introduced by the Curtice Nursery Company, Portland, New York, in 1901 or 1902. It does not appear to have been widely disseminated. Plants were received at this Station from Lewis Roesch, Fredonia, New York.

Plants large, vigorous, upright-spreading, dense, productive, healthy; suckers rather few; canes stocky, smooth, of medium length, straight, dark brown often entirely overlaid with dull gray; leaves ovate, thin, dark green; margin crenate; petiole variable in length averaging about two inches, of medium thickness, pubescent; season of bloom early. Fruit matures early in July, easily picked; clusters long, loose,

with from fifteen to twenty-four berries per cluster; stems and pedicels long, slender; berries adhere well, medium to large, often one-half inch across, roundish to slightly oblate, attractive light bright red; skin smooth, thin, tough, translucent; flesh reddish, medium juicy, fine-grained, tart, sprightly; very good; seeds intermediate in size and number.

STRAWBERRIES.

Indiana is a new variety which for two years in succession has been a leader among nearly one hundred varieties under test on the grounds of this Station. The plants do not multiply as rapidly as could be wished but are up to the average in this respect. It blooms late — a valuable character in localities subject to late spring frosts. The season is medium early. The blossoms are perfect. The plants thus far are healthy and although only medium in vigor have yielded well on the heavy clay soil at this Station producing in 1913 at the rate of 10,436 quarts per acre. It is reported to be more productive on heavy than on light soils. But few varieties surpass Indiana in size of fruit, this character holding up unusually well throughout the season. Some of the earliest berries are " coxcombs " but the prevailing shape is distinctly that of the wedge. The color is somewhat variable at first but later becomes a uniformly dark, glossy scarlet. The quality is first-class. The variety gives promise of being one of the best of shippers, having firm, meaty flesh.

Indiana is of recent origin. It was produced by Mr. H. J. Schild, Ionia, Michigan, in 1905. It is a cross between Red Cross and a seedling, the parentage of which was Red Dawn X Ionia Market. The new variety was introduced by Mr. A. B. Sibert, Rochester, Indiana, in 1911 as a " fig type " strawberry.

Plants medium in number, vigor and height, healthy, productive; leaves rather small, dark green, smooth, glossy; leaf-stalks somewhat slender, with abundant pubescence; flowers perfect, bloom rather late, variable in size; pedicels short, slender slightly pubescent; petals average six to seven in number, broadly roundish, tapering to broad, blunt claws; stamens numerous, short; receptacle medium in size, broadly conical. Fruit-stems short, thick, prostrate, much branched; pedicels long, slender; calyx small, flat, adheres well to the fruit; fruit matures medium early, season rather long; berries large, quite uniform in size which is retained till near the close of the picking season, wedge-shape, with furrowed surface, not necked, obtuse at the apex, dark attractive glossy red, coloring evenly; seeds numerous, variable in position; flesh well colored to the center, medium juicy, firm, mild subacid; good in quality.

Barrymore.— For two years at this Station, Barrymore has more than held its own against many standard, commercial strawberries. The characters which promise to make it preeminent are fruitfulness, large size, desirable shape, unusually attractive color, with flavor and quality which closely rival these characters in the well-known Marshall. The foliage has shown some susceptibility to leaf-spot. In the later pickings the color of the fruit has been somewhat variable. The yield at this Station in 1913 was at the rate of 12,499 quarts per acre. The late blooming habit is a valuable asset in localities subject to spring frosts. The flowers are perfect. A large number of runners are produced, for which ample room should be provided in setting the plants. Barrymore is almost an ideal variety for early midseason.

Barrymore is the result of a cross made by Mr. H. L. Crane, Westwood, Massachusetts, in 1901. Blossoms of Sample were fertilized with pollen from a seedling of A. B. Howard. After testing the seedlings resulting from this cross for a number of years one of the most promising was named Barrymore and was introduced by Mr. Crane in 1908 in which year the variety won a silver medal and three first premiums at the meeting of the Massachusetts Horticultural Society.

Plants numerous, medium in vigor and height, very productive, somewhat subject to attacks of leaf-spot; leaves rather small; flowers perfect, bloom rather late, one to one and one-eighth inches across; petals roundish-oval, usually from six to eight in number; stamens medium in length, numerous; fruit-stems intermediate in length, variable in thickness; calyx large, attractive green, flattened, leafy. Fruit matures medium early, season long; berries large, retain size fairly well till near the close of the season, blunt-conic to wedge-shape, obtuse at the apex, attractive, glossy dark red; seeds raised; flesh well colored to the center, juicy, firm, pleasant flavored, sprightly; very good in quality.

RINGING FRUIT TREES.*

G. H. HOWE.

SUMMARY.

1. The object of ringing fruit trees is to induce unproductive trees to set fruit.

2. Briefly stated, the theory of the operation is: That the removal of a band of bark through the cortex and bast of a plant, at the period of most vigorous growth, does not hinder the upward passage from the roots to the leaves, through the outer layer of woody cells, of unassimilated sap; but does prevent the distribution, through vessels in the cortex and inner bark below the wound, of assimilated food. The effect of this action is to cause an extra amount of reserve material to be stored in the upper parts of the plant for the production of fruit buds.

3. Ringing seems to favor certain organs for a time but devitalizes others.

4. The removal of narrow strips of bark is less injurious to plant growth than taking out wide rings.

5. Under certain conditions, ringing may induce and possibly increase fruitfulness of apples, but it rarely has these favorable effects on other fruits.

6. Only young and very vigorous apple trees, possibly now and then pear and cherry trees, can survive ringing, and even with these fruits the compensating gains seldom offset the injury to the trees.

7. The practice of ringing stone fruits should never be followed. The experiments indicate almost 100 per ct. loss in the life of the trees.

8. Regular and successive increases in productiveness did not result from the ringing of several varieties of our tree fruits.

9. Ringing had no apparent influence upon the size, color or maturity of apples.

10. The general effect of ringing on the roots of the trees was to decrease their size and number and to lessen their vigor.

INTRODUCTION.

Ringing plants consists in the removal of a band of bark through the cortex and bast of the trunk. The term girdling is frequently used

* Reprint of Bulletin No. 391, December; for Popular Edition see p. 956.

to designate this operation, but since this name is usually associated with wounds made more or less deeply in the wood, which result in ultimate death, as when a tree is girdled by mice or girdled for the purpose of killing, it is unfortunately chosen. French writers use the phrase, "décortication annulaire" (annular decortication) which is more exact than either ringing or girdling.

The object of ringing is to induce and increase fruitfulness. In the growth of plants, unassimilated sap rises from the roots through the outer woody cylinder of the main stem to the leaves. There it is changed into a suitable form for utilization in plant growth. This sap is then distributed, through cells in the cortex and inner bark, to the various plant organs. When plants are ringed the upward flow of sap is not materially impeded, but returning juices are prevented from passing below the wound. This causes an unusual accumulation above, thus supplying the upper portion of the plant with an extra amount of food at the expense of the parts below the ring.

The practice of ringing is by no means of recent origin but is known to have been in use at least a century ago for the purpose of increasing productiveness of woody plants. Thus, according to Prince,[1] writing in 1832, Lindley, in his *Guide to the Orchard and Kitchen Garden,* advocated its use to bring fruit trees into bearing. Sorauer[2] discussed at length the principle involved and the practicability of the operation. Goodman[3] considered ringing just as important in the scheme of orchard management as pruning and cultivation. According to his experiments with a large number of trees the crop was increased five fold. Van Deman[4] recommends the ringing of apple and pear trees only when all other means of inducing them to bear have failed. He discourages the practice of the operation with stone fruits. Paddock[5] found that with certain varieties of grapes ringing produced an increased size of cluster and earliness of ripening but the operation was too devitalizing to be recommended as a common practice. Daniel[6] found that the annual ringing of tomatoes and egg-plants produced a marked increase in the size of the fruits borne. Sablon[7] ringed various

[1] Prince, William. Pomological Manual. 2:X–XI. 1832.
[2] Sorauer, Paul. Physiology of Plants, pp. 159-164. 1895.
[3] Goodman, L. A. N. Y. State Fruit Growers' Assoc. An. Rpt. 5:59. 1906.
[4] Van Deman, H. E. *Rural N. Y.* 73:1181. 1914.
[5] Paddock, W. N. Y. Sta. Bul. 151:1898.
[6] Daniel, L. *Compt. Rend. Acad. Sci.* (*Paris*) **131**:1253–1255. 1900.
[7] Sablon, Leclerc du. *Compt. Rend. Acad. Sci.* (*Paris*) **140**:1553–1555. 1905.

woody plants in order to determine the distribution of the reserve plant juices contained therein. Hedrick, Taylor and Wellington,[8] in a bulletin from this Station, found that ringing herbaceous plants was so deleterious to their growth that it could not be advocated for general practice. The loss to the plants was great and there proved to be little or no compensating gain.

The object of the experiments herein reported was to determine, if possible, the extent to which fruit trees can be ringed without permanent injury and in what degree, if at all, the operation induces and stimulates fruitfulness. Apples, pears, plums and cherries were the species used in these experiments. The work was started in 1910 and was carried on during the three succeeding years.

Ringing should be performed early in June or July, at which time the bark peels readily from the wood leaving the cambium in a succulent condition. The success of the operation hinges upon the fact that at this season of the year occurs the greatest cambial activity which readily facilitates the rapid formation of new bark and at the same time prevents exhaustive evaporation of plant juices. Any attempt to practice ringing when plant growth is sluggish or dormant always results in the death of the tree, since the cambium, being then firm, is torn from the woody cylinder during the operation. A common pruning knife or a sharp pocket knife is a suitable instrument for performing the operation. The rings were made of varying widths and were cut either at the base of the trunk or upon branches close to their union with the trunk. In one case narrow rings were made around the trunks at different distances from the surface of the ground.

RINGING APPLES.

In 1910 there were growing upon the Station grounds 122 seedling trees five years from planting, which up to this time had borne little or no fruit. Early in June, 1910, a band of bark one inch in width was removed from the trunk of each of these trees, just above the surface of the ground. These were normal, vigorous young trees, free from insect pests and diseases, and all were making a strong, thrifty growth. All received similar treatment as to cultivation and pruning. New bark began to form within a few days after the ringing and at the end of the growing season all of the wounds were entirely covered with new, healthy bark. As far as could be noticed, none of the trees

[8] Hedrick, U. P., et al. N. Y. Sta. Bul. 288. 1907.

had received any setback in the season's growth. All were vigorous and had made considerable new growth. Table I shows the number of bearing trees and the percentage of a crop per tree for the years 1910 and 1911.

TABLE I.— EFFECT OF RINGING ON FRUIT PRODUCTION OF APPLE TREES.

1910.				1911.		
No. of trees ringed.	No. of bearing trees.	Percentage of trees bearing.	Average percentage of crop per tree.	No. of bearing trees.	Percentage trees bearing.	Average percentage of crop per tree.
122	54	44	7	107	88	56

These figures would seem to indicate that ringing, according to theory, exerted a very potent influence in bringing the trees into bearing and upon the fruitfulness of the trees. Manifestly, without ringing and with the same climatic conditions a larger number of trees would have fruited in 1911 than in the previous year, because of increasing maturity; and the crop per tree would likewise have been increased. Nevertheless, it is doubtful if such a marked increase in the number of bearing trees and in productiveness would have occurred, had not the setting of fruit-buds been stimulated owing to an interruption of physiological functions. It may be well to state at this point that since 1911 these trees have never yielded as large a crop even with subsequent ringing.

In the early part of June, 1911, 27 of the seedling trees which had been ringed the previous year were again subjected to the removal of a strip of bark one inch in width directly above the former rings. The bark peeled off from the wood this year with as great ease as it had before. Within a few days new bark was seen to be forming from the hardened cambium over the entire surface of every wound. At the end of the growing season an entire, new coating of bark was joined to the old upon either side of the ring. Apparently the trees had suffered no ill effects from the ringing. All seemed to be in a vigorous, thrifty condition and upon comparison with unringed trees no difference could be found in the amount of growth.

The 27 trees ringed produced in 1911 an average of 93 per ct. of a crop per tree and in 1912, 43 per ct. From these figures the fact

Fresh ring, one inch wide. New bark on one-inch ring. Three-inch ring with new bark.

PLATE LV.—APPEARANCE OF RINGS ON APPLE TREES.

stands out clearly that the heavy crop in 1911 resulted in an off-year and a light yield in 1912, as is so often the case with many standard varieties of apples. The second ringing apparently had no influence in increasing the yield. The health and vigor of the trees seemed not to be decreased. All except two showed, at the close of the season, complete new bark formation. The two trees in question had failed to cover the entire ring and were not as vigorous as the others. It is possible that these trees lacked vigor from the time of planting.

In the early part of June, 1912, additional ringing was performed upon these same trees. This time rings 3, 6, 9, 12, 15, 18 and 21 inches in width were made, four trees being used for each of the various widths. These wounds were made around the trunks just above the former rings, all of the bark, whether in three-inch strips or twenty-one inch strips, being removed with equal ease. This ringing had no effect upon stimulating fruit production, for the crop borne in 1913 was about the same as that of 1912—so similar that further averages need not be given. Table II explains the effect of the ringing upon the vigor of the trees.

Table II.— Effect of Ringing on Vigor of Apple Trees.

No. of trees with various sized rings.	No. of trees fully healed.	No. of trees partially healed.	No. of trees failing to heal.	No. of vigorous thrifty trees.	No. weakened in vigor.	No. of trees entirely dead.
4 trees ringed 3 in. wide..	3	......	1	3	......	1
4 trees ringed 6 in. wide..	3	......	1	2	1	1
4 trees ringed 9 in. wide..	3	1	......	2	2	......
4 trees ringed 12 in. wide..	2	2	......	2	2	......
4 trees ringed 15 in. wide..	3	1	......	2	2	......
4 trees ringed 18 in. wide..	3	1	......	2	2	......
4 trees ringed 21 in. wide..	1	3	......	1	3	......

From the foregoing data it would appear that ringing tends to have injurious effects upon apple trees and that the wider the bands the more serious will be the injury. It may be stated again at this point that the trees used in this experiment were exceptionally strong and uniform in vigor and were therefore possibly in a better condition to withstand wounding than average orchard trees. All of the trees making a weak growth showed smaller foliage and less wood produc-

tion. The foliage, likewise, lost its color and fell from the branches four to six weeks earlier than that of normal trees. Sprouts two to six in number sprang up at the lower edge of the wound on nearly every tree. This would indicate that nature was endeavoring to provide assimilated food for the roots since passage of such food from the upper portion of the trees had been cut off. As has already been stated no gain in productiveness resulted from this ringing. The few fruits which were produced showed no differences in size or color from the normal. Clearly, ringing these trees seriously injured their health without increasing fruitfulness. Orchard space necessitated the discarding of these trees in 1914. Examination, at this time, of the root systems showed that, as a rule, the ringed trees had smaller, shorter roots (nearly approaching hairy roots) than the unringed trees. Trees low in vitality had extremely small root systems.

Early in June, 1911, 50 Baldwin trees three years from setting were ringed, bands 2, 4, 6, 8, 10, 12, 14, 16, 18 and 20 inches wide, respectively, being removed from groups of five trees each. At the same time 35 trees of the same variety and age in another block were ringed, groups of five trees each being ringed with one-inch-wide rings at the surface of the ground and 4, 8, 12, 16, 20 and 24 inches, respectively, above the ground. In most cases new bark started to form, but at the end of the season not a single tree had made a perfect formation of new covering. Several trees in each lot were dead and all others lacked vigor. All foliage dropped about five weeks earlier than from adjoining unringed trees of the same age. The spring following the ringing, but 10 per ct. of the trees of both lots started growth, and this so weak that death resulted before mid-summer. While these two lots of trees were less vigorous than the seedlings of the previous experiments, they were representative of average trees of the commercial orchard.

About the middle of June, 1912, out of a block of 24 Baldwin trees four years from planting, 12 were ringed one inch wide at the base of the trunks and the remaining 12 were left as checks. These were average Baldwin trees, vigorous and thrifty. None had fruited up to the time of ringing. At the close of the growing season not a single tree showed an entire coating of new bark. All had partially recovered, but lacked vigor and tone. As compared with the checks, the ringed trees had made less growth. The foliage was smaller and dropped earlier. In the spring of 1913, one tree failed to start. All

of the others began growth at the same time as the checks but failed to advance as rapidly. No additional bark was formed and on each ringed tree portions of the new bark died during the summer. At the end of the season the check trees had made one-third more growth than those ringed. The wounded trees were then so weak, one having died, that they were all discarded. All of the living trees, both the ringed and the checks, bore a few apples in 1913 which dropped before the time of harvesting. The root systems of the ringed trees all proved to be much smaller and less developed than those of the checks.

From these experiments it is clear that the first ringing of the seedlings influenced fruitfulness and caused them to set a large crop of fruit. The experiments with the Baldwins, however, showed entirely different results. These trees, lacking the vigor and hardiness of the seedlings, failed to survive a single operation.

In some of the western states orchardists frequently resort to the ringing of their young trees to induce them to bear fruit, with very good results. Under most favorable conditions young, vigorous, thrifty trees ought to withstand and respond to one operation, but subsequent ringing is devitalizing and exerts practically no beneficial influence. From the experiments at this Station, the practice of ringing apple trees for the purpose of inducing and increasing productiveness seems too drastic a practice for the good of the trees. Even if a slight increase in fruitfulness is brought about it seldom offsets the injury to the tree.

RINGING PEARS.

Early in June, 1912, 12 Bartlett pear trees four years from setting were ringed at the base of their trunks with bands one inch in width. Twelve adjoining trees of this variety were left as checks. As with apples, the pear-tree bark peeled from the wood at this season with ease. Succulent cambium covered the exposed woody cells. Soon after ringing, this cambium hardened and began forming bark over the entire wound and no injurious effects were evident. After a time, however, new bark continued to grow only in streaks, leaving patches of dying tissues. Wood growth became sluggish and the foliage failed to retain its usual dark green pigment. In the fall, 2 trees were dead, having formed but 5 per ct. of new bark. None of the others were thrifty. New bark was poorly formed. The foliage was small

and discolored and dropped several weeks earlier than that from the check trees.

In the spring of 1913 the 10 living trees started growth at about the same time as the checks. Growth was slow and as the season advanced more dead bark appeared where the ringing had been done. Towards the end of the summer 4 more trees died. The remaining 6 made such a poor growth that they were discarded at the end of the season. Very marked difference existed in the size of the ringed and unringed trees, the latter being one-third larger and making a rapid, vigorous growth. The roots of the ringed trees were poorly developed. At the beginning of the test the trees were all of equal size and similar to trees of the same age in the best commercial plantations. All received the same treatment. No fruit had been borne previous to the time of ringing. In 1913, however, both lots of trees bloomed in about equal proportions but no fruit set upon any of them, due, possibly, to the self-sterility of this variety.

RINGING PLUMS AND CHERRIES.

Almost no work seems to have been done upon the ringing of stone fruits. In general, drupes come into bearing earlier; are not as hardy; are less resistant to external injuries; and are shorter lived than pomes. The primary object of ringing these stone fruits was to determine in what degree they could withstand the injury, as it was hardly to be supposed that there would be a favorable effect in inducing or stimulating fruit-bearing.

Early in June, 1912, 12 Montmorency cherry and 12 Bradshaw plum trees, four years from planting, were ringed one inch wide at the base of their trunks. No difficulty was experienced in the removal of the bark and, like the pomes, the woody cells were covered with succulent cambium. Twelve trees of each variety in the same block were left as checks. At the same date 20 standard varieties of plums 15 years from setting were ringed. These trees were in an orchard of about 40 varieties all of the same age and receiving the same attention. Rings one inch in width were taken out. Four trees were ringed upon their trunks just above the ground. On the remaining 16 trees the largest branches were ringed close to their union with the trunks. All of the trees were strong and vigorous and free from insects and diseases. During the first few weeks after the ringing the cambium

seemed to be hardening into bark over all the wounds. By midsummer, however, growth had stopped and little or no new bark was evident either on the cherries or plums. The cut edges from many wounds showed growth in the nature of a callus and from these occasionally would extend at right angles short strips of new bark almost meeting at the center of the rings. But the wounds never entirely closed. As the season advanced much of the newly formed bark died. Tree growth became stunted. The foliage began losing color and the general vigor of all the trees seemed impaired. The 15-year-old plum trees set a small crop of fruit in 1912. At the time of harvesting no difference could be found in size and color of the fruit from ringed and from unringed trees. The flavor of fruit from ringed trees, however, seemed not to be so good and the flesh was less juicy. No fruit was borne on the Montmorency cherries or the Bradshaw plums in 1912. At the close of the growing season 80 per ct. of all the trees were without living bark covering the wounds. Usually the woody cells were bare and often they were black and spotted indicating fungus diseases. One cherry tree showed a considerable portion of the wound to be perfectly healed, but this tree lacked the vigor of the unringed trees. Both the cherry and plum foliage fell from the ringed trees from four to five weeks earlier than from the checks. In case the trees were ringed on the trunks the whole tree was in a weakened condition, but where branches only were ringed, these and not the whole tree were low in vitality. Out of all the trees ringed but one, a Montmorency cherry, made any material growth the following season. All of the other cherries and all of the plums which were not entirely dead failed to make more than a start; before summer, all were dead. The Montmorency cherry mentioned, while making fair growth, was by no means as vigorous as unringed trees. An examination of the root systems of the ringed trees showed that they were smaller, shorter and less dense than those of check trees. This was particularly true of the younger trees. With the older plum trees but little difference could be found.

CONCLUSIONS.

The results obtained from these experiments are not favorable to ringing fruit trees as a general practice. Under some conditions, for a limited time, a more favorable outcome might be expected. Hardy, vigorous, young apple trees may readily undergo a single ringing and

be benefited thereby, but subsequent operations are injurious. Trees lacking vigor are often seriously injured by the practice. The deleterious effects of the treatment have generally been so marked upon various plant organs as to render the operation exceedingly hazardous. There seems to be no regular or systematic increase in fruit production. The gains do not offset the losses.

DISTRIBUTION OF STATION APPLES.*

U. P. HEDRICK.

The New York Agricultural Experiment Station has twelve new varieties of apples for distribution in 1914. These varieties are the outcome of experimental work in plant breeding. They have been grown and compared with practically all of the standard sorts of their kind and are equal to or superior in one or more respects to apples of their season, as grown on the Station grounds. The distribution of these varieties is undertaken that we may ascertain their value and adaptability in the different fruit regions of New York. A fuller description of most of the varieties listed has been published in Bulletin No. 350 from this Station.

TERMS OF DISTRIBUTION.

There are no restrictions upon recipients of plants as to further distribution of the varieties by sale or otherwise. If the fruits prove meritorious, it is desired that they be generally disseminated as quickly as possible. We only ask that those who receive the plants report to the Station in regard to the behavior of the varieties on blanks which will be furnished when the plants come in bearing.

The trees are sent without charge but the recipient must pay expressage. Applicants must give both mail and express addresses.

The Station reserves the right to make a choice of growers to whom the trees will be sent. This choice will depend chiefly upon priority of application and upon the number of applicants from a locality.

Only one tree of a variety can be sent to an applicant, but it is desired that a person receiving any should receive all of the varieties, that a comparative test may be made of them.

The trees have been fumigated and the tops have been dipped in an insecticide but the Station does not guarantee them to be free from San José scale.

Address all correspondence regarding these new fruits to the Horticultural Department, New York Agricultural Experiment Station, Geneva, N. Y.

* Reprint of Circular No. 28, March 9.

STATION APPLES.

Broome — (Parentage unknown). Tree vigorous, upright-spreading, rather late in coming into bearing, medium in productiveness. Fruit comes in season early in January; above medium to medium in size, roundish to oblate-conic, usually completely overspread with dark red; flesh yellowish, firm, medium in grain, moderately juicy, mild subacid, aromatic; good in quality. Worthy of test because of attractive color and high quality.

Clinton — (Ben Davis × Green Newtown). Tree vigorous, upright-spreading, productive. Season, December to February; above medium in size, roundish to oblate-conic; color greenish-yellow, blushed with dull bronze, splashed with carmine, prevailing effect red; flesh yellowish, firm, crisp, tender, juicy, subacid, aromatic; of good quality. This apple is very attractive in appearance and of very good quality, resembling Green Newtown in size, shape and quality but of a handsome red color.

Herkimer — (Ben Davis × Green Newtown). Tree vigorous, upright, slightly spreading, medium productive. Season, December to March; large, roundish to oblong-conic; color greenish-yellow, partly overspread with red, irregularly splashed and striped with dull carmine; flesh yellow, firm, coarse, juicy, brisk subacid; of good quality. Herkimer resembles Ben Davis both externally and internally more than the Green Newtown but is better in quality. Its good quality, handsome appearance and long-keeping properties commend it.

Montgomery — (Parentage unknown). Tree vigorous, upright-spreading, dense-topped, produces heavy crops biennially — light crops in other years. Fruit matures about the middle of September, or soon after Red Astrachan; large, roundish to oblate-conic, almost entirely overspread with bright red and faintly striped with darker red resembling Red Astrachan; flesh white, fine-grained, tender, juicy, brisk subacid; good in quality. An early variety, much like Red Astrachan but extending the season of that variety.

Nassau — (Esopus × Ben Davis). Tree vigorous, upright-spreading, productive. Season December to March; medium in size, oblate; color pale yellow, splashed, striped and mottled with bright pinkish-red, blushed on the sunny side; flesh firm, coarse, juicy, crisp, pleasant subacid, aromatic; good in quality. Nassau is far better in quality than Ben Davis but is hardly equal to Esopus. The color is more like that of Ben Davis than of Esopus, the contrasting colors of red and yellow being most attractive.

Otsego — (Ben Davis × McIntosh). Tree vigorous, upright-spreading, productive. Season November to February; medium in size, oblong-conic; color pale yellow overspread with mottled dark red, splashed and striped with carmine, prevailing effect red; flesh yellow, firm, crisp, tender, medium juicy, mild subacid; good in quality. This apple is propagated because of its handsome color, good quality, small core and sparsity of seed.

Rensselaer — (Ben Davis × Jonathan). Tree vigorous, spreading, productive. Season December to February; medium in size, roundish-conic to truncate; color yellow with a dull red blush, splashed with carmine, prevailing effect red; flesh yellowish, firm, crisp, tender, juicy, subacid, aromatic; of good quality. While of but medium size, Rensselaer is so attractive in color and of such high flavor as to make it a valuable dessert fruit. It is of the type of Jonathan both externally and internally.

Rockland — (Ben Davis × Mother). Tree of medium vigor, somewhat spreading and straggling, productive. Season November to January; of medium size, roundish-truncate, symmetrical; color yellow, entirely overspread with dark red, splashed, mottled and obscurely striped with carmine; flesh yellowish, coarse, crisp, tender, juicy, sprightly subacid, aromatic; good to very good in quality. The fruit of this cross is of the type of Mother. It is most pleasing in appearance, resembling Mother in size, shape, color, texture, flavor and quality. This apple ought to be especially valuable as a dessert fruit.

Saratoga — (Ben Davis × Green Newtown). Tree vigorous, upright-spreading, dense-topped, productive. Season January to April; large, roundish-conic to oblate, ribbed; color greenish-yellow, overspread with bright purplish-red, splashed and mottled with crimson; flesh greenish-yellow, firm, coarse, crisp, tender, juicy, subacid, sprightly; of good quality. This apple is particularly valuable because of its bright color and large size. Its quality is much superior to Ben Davis, being nearly or quite as good as Green Newtown.

Schoharie — (Ralls × Northern Spy). Tree vigorous, upright-spreading, productive. Season November to March; large, roundish-conic, ribbed; color greenish-yellow, overspread with a mottled and striped dull red, prevailing effect, dull, striped red; flesh yellowish, firm, fine-grained, crisp, tender, juicy, pleasant but mild subacid, aromatic; of good quality. Schoharie is of proper size but somewhat dull in color. It is the type of Northern Spy in shape and color; the flesh, too, is that of the Northern Spy, more yellow, but having the same delicious flavor and aroma.

Ulster — (Parentage unknown). Tree medium in vigor, upright-spreading, somewhat slow in coming into bearing, after which there is a tendency to overbear. Fruit begins to mature the last of December or early in January, season long; medium to above in size, roundish-oblate, green or greenish-yellow, sometimes with faint bronze blush; flesh tinged yellow, fine-grained, crisp, tender, juicy, pleasant subacid, aromatic; good to very good in quality. A greenish-yellow, late apple, usually of medium size, unless thinned; desirable on account of good keeping qualities and high flavor.

Westchester — (Ben Davis × Green Newtown). Tree vigorous, upright-spreading, productive. Season November to January; large, roundish-conic, ribbed; color yellow, overspread with dull red, mottled and splashed with darker red; flesh yellow, coarse, very tender, juicy, mild subacid, aromatic; good to very good. Westchester resembles Green Newtown in shape, but has the color of Ben Davis while the quality is even better than that of Green Newtown.

CULTURE OF SWEET CORN.*

J. W. WELLINGTON.

NEEDS OF THE PLANT.

Climate.— Corn is preeminently a hot-weather plant and makes its best growth during the summer months. It is tender and easily killed by late spring and early fall frosts, hence in the northern part of the State it is a somewhat doubtful crop except with the early maturing sorts.

Soil.— Sweet corn will grow and do well in various types of soil, thriving best in light soils which warm up quickly in the spring. Good drainage is of utmost importance — more so than with cooler-climate vegetables such as cabbage and potatoes. A gentle, sunny, south slope is ideal for hastening the maturity of early sorts. The prospective corn field should be fall plowed unless there is danger of soil washing.

Fertilizers.— Plenty of available plant food must be supplied. Market gardeners prefer horse manure to cow manure for the early sweet corn crop since the former, by virtue of its lighter and heating nature, opens and warms the soil. For midseason crops, abundant use of any manure procures good results. Supplemental applications of commercial fertilizers should be made in order to insure heavy yields. Where no manure is available, corn should follow clover or other legumes in a rotation and should receive a liberal application of a fertilizer with a high content of phosphorus and nitrogen. The grower must ascertain the needs of his soil for himself, the appearance of the plants and the yield thereof being the best index of the soil's condition. Manure should be plowed under, and the commercial fertilizer broadcasted before final harrowing. It suffices to say that the better the preparation, the better the crop.

CULTURE.

Planting.— Small fields may be planted on a square system, allowing horse cultivation in both directions. This method of planting results in a great saving of hand labor, in that the cultivator reaches a greater part of the weeds. Large fields must necessarily be planted by machinery, and allow of tillage in one way only. These machines may be regulated to required depth, number of seed and distance between hills and are by all means recommended for extensive plantings. There are also good hand sowers which

* Reprint of Circular No. 29, May 10.

make the hole and drop the required seed at one operation. Two to three inches depth is proper for sweet corn. Large-growing varieties, as Evergreen, should be sown in hills at least three and one-half feet apart; small kinds, as Cory, three by three or even less. Crowding gives no gain, resulting in taller plants of less yield. Eight to twelve quarts of seed is required for one acre. Six kernels should be sown in each hill, thinning to three or four plants at time of first hoeing.

Care of crop.— Cultivation must begin as soon as the young plants show the rows and be continued at frequent intervals until the corn leaves are liable to injury. Since corn makes rapid growth in the driest, hottest months, it is imperative to keep up cultivation sufficient to maintain a dust mulch. The first hoeing is done when the plants are three or four inches tall and should be repeated often enough to kill all weeds. Proper tillage will bring a crop to successful maturity through all ordinary droughts.

Harvesting.— Sweet corn is ripe for table use when the kernels first become plump and full of milk, about the time that the silk has turned dark brown. Early varieties begin to ripen in early July and there are plenty of succeeding kinds to carry the season until fall frosts. The delightful sweetness soon deteriorates after picking, the consumer in the city receiving an inferior article after it has spent a few days in the market. Market gardeners generally pick twice; the home gardener greatly extends this season by starting with the earliest ears. The yield per acre depends upon the variety and degree of culture practiced. The trade prefers a medium sized ear. Retail trade is highly profitable and may be greatly strengthened by the use of attractive packages containing a definite number of ears and bearing the name of the variety and that of the grower.

SECURING GOOD SEED.

Seed.— In order to maintain the good qualities of a variety it is necessary to practice systematic selection. For instance, if earliness is the object desired, the grower should go through his field and select those plants bearing the first maturing ears and distinguish such plants with colored string or cloth. Upon harvesting, these plants are not touched and their ears are left to ripen on the stalk. This seed should be separately cured, re-selected for ear qualities, and sowed in a distinct plat the next season. Selection is continued in this improved plat and after three or four years the grower will find himself possessed of a superior strain. Pearl and Surface give an admirable discussion of sweet corn breeding in Bulletin 183 of the Maine Station. This selective work is of no avail where two or more varieties of corn are grown within the vicinity of one another as varieties have been known to mix at distances of more than a mile.

Care of seed.— Curing the seed is an important process; poor methods may easily result in loss of all gain derived from care in growing. The seed ears may be picked when the husks are dry and withering. They should be either laid away in a wire-screen, vermin-proof rack or suspended by the husks from the rafters of an attic or other dry, warm room. Each ear must be so placed that it does not come in contact with others. After becoming thoroughly dry, the kernels should be shelled and laid away in a dry vermin-proof situation.

Sweet corn growing deserves more careful thought and study. The ears are used for human food and the fodder is excellent for cattle. By reason of its many uses sweet corn is, almost without exception, a paying crop and often returns handsome profits. Large acreages are grown in this State for canning and market purposes. The practice of home selection of seed and the use of more thorough cultural methods would bring thousands of dollars in additional returns to the growers.

A FEW GOOD VARIETIES.

Cory.— Season very early, early July to August. Plant 4 to 5 feet tall. Ears 6 to 8 inches; 8 rowed; kernels large, white, with slight reddish tinge. Cob red. Quality good. Grown for market and home use on account of its earliness.

N. B.— There is also a White Cory, with white cob and dull white kernels of quite similar quality. Not as hardy.

Golden Bantam.— A few days later than Cory. Plant 4 to 5 feet tall. Ears 5 to 7 inches; 8 rowed; kernels large and broad, golden-yellow when edible. Quality delicious. A home garden sort of increasing market value. The best variety for the table.

Crosby.— Second early sort. Plant 5 to 7 feet tall. Ears 7 to 8 inches; 12 or 14 rowed; kernels long, white. Cob white. Quality very good. A desirable home, market and canning variety.

Country Gentleman.— Main crop or late. Plant 6 to 7 feet tall. Ears 6 to 9 inches, 18 to 24 irregular rows; kernels long, slender, "shoe-peg" shape, white. Cob white. Quality excellent. Grown for home and market.

Evergreen.— Stowell's Evergreen. Standard late sort. Plant 6 to 8 feet tall. Ears 7 to 10 inches; 14 to 18 rowed; kernels long, medium size, white. Cob white. Quality very good. Grown for home and late market.

STRAWBERRIES.*

O. M. TAYLOR.

CULTURE.

Location and soil.— In the selection of a suitable location for strawberries several important factors should be considered such as climatic conditions, distance to market, kind of market, labor supply, character and condition of soil and need of drainage. Strawberries do well under widely different climates and soils. Most varieties, however, prefer lighter, sandy loams rather than colder and more compact clay soils. A well-drained loamy soil containing an abundance of available plant food and humus is especially desirable. A lighter soil with a southern exposure favors early crops. The heavier clay loams and a northern exposure are preferable for the late crops. If there is danger of spring frosts an elevation may be safer than bottom lands. A chemical analysis of soil will not determine its value for the strawberry crop.

Preparation of soil.— Weedy soils increase the expense of growing the crop and decrease the yield. Hoed crops such as potatoes, cabbage, beans or corn preceding strawberries will leave the land freer from weeds; and the soil will be in better condition if manure be applied heavily for the preceding crop. Seldom is land made too rich for strawberries. A clover sod plowed under is of great value but a grass sod should be avoided on account of danger from insects destructive to the roots of strawberry plants. Deep plowing will cause the plants to root more deeply and conserve more moisture. It may be done in spring but preferably in the fall as there is usually more time then, the decay of sod or fresh stable manure will begin sooner, beneficial effects from the action of frost on clay soils will be secured, insects may be destroyed, the soil made capable of holding more moisture and the spring work may be started earlier. In some cases it may be desirable to re-plow in the spring or the ground may be worked down with disk and harrow. Thorough cultivation should be given to make the soil fine and mellow before setting the plants.

Manure and fertilizers.— There is but little danger of too much plant food in the soil. To secure maximum yields there must be an abundance of readily available food. Well-rotted manure thoroughly worked into the soil is one of the best fertilizers. Coarse manure will give good results if turned under early enough to become well decomposed in time to supply the needs of the plants. Such material is valuable because of its humus which improves the physical condition of the soil and also its ability to withstand drought.

* Reprint of Circular No. 31, November 15.

The absence of humus often accounts for low yields, especially in dry seasons. Fresh stable manure may occasionally be the means of introducing weed seeds into the soil. Applications of from 18 to 20 tons of manure per acre are none too heavy and they may often be increased with advantage.

It is at times advantageous to use commercial fertilizers. The kind and amount to use, the time and manner of application depend on conditions. The applications should bear some relationship to the character of the soil, of the season, of the method of growing the crop and of the variety of strawberry grown. Soils may lack nitrogen, potash or phosphoric acid. Two to three hundred pounds per acre of nitrate of soda or 300 to 600 pounds dried blood will stimulate growth. An excess of nitrogen may cause a rank growth at the expense of fruit. Potash may be supplied by wood ashes, 2,000 pounds per acre, or by two to three hundred pounds muriate of potash. Six to seven hundred pounds per acre of acid phosphate will supply any lack of phosphoric acid. Other fertilizers might be named. If the soil is already well supplied with any one of these forms of plant food it is useless to make additional applications of that kind. The need of each soil should be studied and it is desirable to make tests of different fertilizers leaving check rows for comparison. Fertilizers will not take the place of humus.

No rule can be given for the proper application of fertilizers. Soils differ in all their properties and the condition should govern the application. Each grower must use his own judgment, based on observation and experience, to determine what to apply. The fertilizer may be applied broadcast in the spring before setting the plants, harrowing it in, or scattered along the plant rows after setting and mixed with the soils by cultivation. If necessary, nitrate of soda may be given the fruiting beds before blossoming time, broadcasting it directly over the plant rows. The foliage should be dry at time of application or injury may result, especially if nitrate remains on the leaves. For second crop beds apply the fertilizer or rotted stable manure along the rows after they have been cleaned out following fruitage. Strawberries do not appear to respond favorably to applications of lime. Some experimenters have observed more or less injury by its use.

VARIETIES.

Selection.— A variety may succeed admirably in one place and yet be worthless elsewhere. Under different environments and under unlike surroundings the same variety may change both in plant and fruit habits. Adaptation should be determined before an extensive use in the commercial plantation. Information may be gathered as to what varieties to set — first, by observation of the kinds doing well in the immediate locality under apparently similar conditions and, second, by a trial of a few plants before setting

extensively. The character of the market may affect the selection; it may require early or late kinds. No variety has all the qualities equally developed that go to make perfection. The newer, most promising kinds should be tested in a small way and their local value determined. Occasionally one may be found superior to the older varieties.

Fall-bearing varieties.— During the past few years considerable interest has been aroused in this and other States to a group of varieties called Everbearing, or Fall-bearing, varieties. Such kinds have a tendency to bloom continuously from early summer until late fall, and are grown in such a way as to mature the bulk of the crop in August, September and October. There are over a dozen such varieties on the market and it is possible to have the fruits maturing during the fall months, and to supply the table for home use. It is another question, however, if such kinds are to be grown extensively for commercial purposes. There may be a limited demand which can be supplied at prices ranging from 25 cents to 50 cents per quart. It is suggested that those who wish to grow this class of varieties begin in a small way, testing out the value of the several kinds, and increasing the size of the plantation as is warranted by the success of the undertaking. The culture is the same as for other strawberries except that the blossoms should be kept picked off the plants up to the middle or last of July, and special steps should be taken to have the soil rich and full of humus. Several of the fall-bearing varieties make but few runners and should be set closer than those that multiply more rapidly. The following is a list of some of the Fall-bearing kinds: —

Fall-Bearing Varieties.

Advance	Francis	Productive
Americus	Iowa	Progressive
Autumn	King Autumn	Repeater
Dewdrop	Onward	Standpat
Forward	Pan American	Superb

Sex of plants.— The sex of the variety should be known. Some varieties have perfect blossoms, also called hermaphrodite, staminate, bi-sexual or male. Such kinds bear flowers containing both stamens and pistils, the center being a collection of many pistils surrounded by short tube-like parts called stamens, at the ends of which is produced the pollen. All such varieties bear fruit when planted alone. Other varieties have imperfect blossoms, also called pistillate or female. Such flowers lack the stamens. These varieties will not bear fruit if grown by themselves with none of the other kind in the neighborhood. About one row of the perfect-flowering varieties is required to every two or three rows of the imperfect-flowering kinds to insure fertilization of the blossoms.

The blossoms are usually fertilized by bees and other insects.

In visiting the perfect flowers the insects become more or less covered with the sticky pollen which is carried by them to other blossoms and is left on the pistils, which are thus fertilized. Incomplete pollination is usually indicated by the presence of nubbins — berries with hard, greenish, undeveloped apex. The absence of pollen-distributing insects at blossoming time, too much rain, frost, or prolonged cool temperatures may greatly decrease the setting of the fruit and increase the number of nubbins. The color, size, flavor or quality of the fruit is not influenced by pollen from other varieties, nor can it be said that all perfect-flowering varieties are more productive than the imperfect-flowering kinds, nor is the reverse true.

STARTING THE PLANTATION.

Selection of plants.— The best stock obtainable should be used. Plants from old beds are usually weakened in vitality and may be infested by insects or diseases. Vigorous, healthy plants should be selected from beds that have not fruited and plants from the earlier runners are usually larger and stronger than from those developing later. Pedigreed plants are supposed to inherit from their ancestors desirable characters which have become fixed and which are repeated without change year after year. This has not been proved to be true, however, and it is not advisable to invest in such plants. Recent experiments [1] carried on for twelve years have failed to prove the value of pedigreed strawberry plants.

Time of planting.— Spring setting is usually preferable as it shortens the time from planting to fruitage and also secures better weather and soil conditions, making it necessary to give but one winter's protection before a full crop of fruit is secured. Fall setting in dry seasons often results in considerable loss of plants. Pot-grown plants may be used in the fall with less risk of loss but the price is usually much too high for profitable returns, although it permits the taking of an early crop from the land before setting to strawberries.

Systems of planting.— The matted row, hill, single hedge or double hedge system may be used, but for most purposes the matted row system is preferable. Plants may be set and treated to make wide or narrow matted rows. The narrow matted row is generally preferable — the rows from three to four feet apart and the plants from eighteen to thirty inches apart in the row, depending on the character of the variety as a plant-maker. The "hill" system consists in both rows and plants being set closer — twenty-four to thirty inches for the rows and twelve to eighteen inches for the plants, removing all runners that develop. Fruit from such plants is usually larger but the labor is greater. In the "single hedge" system the rows are from two to three feet apart with the plants

[1] Missouri Station Bul. 117 (1914).

twenty to thirty inches apart. Each plant produces two runners which are trained to take root in the plant row directly in front of and behind the mother plant. The " double-hedge " system has the rows about three feet apart with the plants thirty inches apart. The mother plant develops through its runners from four to six plants trained to form three rows, one in line with the older plants and a new row each side of the mother plant row. No other plants are permitted to develop. There are many modifications of these methods of planting. Of all these systems the matted row requires less labor and the yield is usually greater.

Setting the plants.— After the plants have been dug they are trimmed for setting by removing all dead leaves and runners and all except one or two of the green leaves. The roots are usually shortened back about one-third their growth. The land should be marked both ways, or across the direction of the rows if the plants are set along a line stretched from end to end of the row. The roots of the plants should never be allowed to dry out. A trowel, flat dibber, or narrow, well scoured spade may be used to open the soil for the plants, the latter being most convenient for large plantings. Insert the spade and press forward making a wedge-shaped opening. The roots, spread out, may be inserted in this space which should then be closed and the soil pressed firmly against the roots. The crown of the plant should not be so deep as to be covered with earth nor should it be set so high as to expose the roots. It should be level with the surface. If too deep the crown may rot; if too shallow the roots dry out.

MANAGEMENT OF PLANTATION.

Treatment during first summer.— Cultivation should begin when the plants are set and be continued throughout the summer and fall whenever necessary to keep down weeds and to maintain a mellow soil condition. If possible, cultivation should be both ways until runners begin to make plants. Cultivation or hoeing should never be deep enough to disturb the shallow root system. The flower-clusters should be removed as soon as they appear, to secure stronger plants from which runners will develop later. The first runners to start should be encouraged to root by " bedding in " or placing in a position where they will root readily and will not be disturbed by the cultivator. It may be necessary to thin out some of the later ones to avoid crowding because most varieties set too many plants. Some growers stop cultivation early, sowing among the plants oats or barley which die down after the first frosts, forming a slight winter protection. This practice, however, cannot be recommended although a cheap one, owing to the large amount of moisture removed by such a crop, which, in a dry fall, must decrease the vigor of the strawberry plants. Such a winter protection is not sufficient to keep the ground from frequently freezing and thawing.

Winter treatment.— Winter protection of some form should be given for several reasons. It protects the roots against repeated freezing and thawing; mulched soil retains more moisture the following spring; the soil is left in better physical condition; additional plant food is given when coarse stable manure is used; growth is retarded in the spring diminishing danger from late spring frosts; weeds may be smothered out in early spring; berries may be kept much cleaner at fruiting time. Various materials may be used for mulching, that most easily obtained at minimum prices ordinarily being selected, such as coarse, strawy horse manure, marsh hay, wheat or oat straw, swale grass, leaves for small beds, or even corn stalks if nothing else is available. The best mulch is one that may be spread rapidly and evenly, will furnish the desired protection and yet will not injure the plants nor introduce too many weed seeds. The mulch should be applied to the entire surface of the ground as soon as it is sufficiently frozen to bear a wagon. A light coating an inch or two deep that covers the plants out of sight is preferable to one of greater depth.

Treatment during fruiting season.— The mulch should remain over the plants as long as possible in the spring. On the approach of warm weather it may be necessary to shake up the covering one or more times to prevent the plants from smothering, placing a portion of the material, if too thick, between the rows. The plants should grow up through the mulch left on the ground. Later in the spring it may be necessary to hand-pull the larger weeds after a soaking rain. Occasionally it may be necessary to remove the mulch and give thorough cultivation, replacing it before the berries ripen.

Renewing old beds.— It is usually better to set new beds each year than to continue the old ones. This, however, depends on the condition of the bed. Under favorable conditions two and sometimes three profitable crops may be harvested. Berries ripen slightly earlier and average smaller on old beds, and there is more danger from insects and disease. It usually costs more to rejuvenate an old bed than to set a new one. A quick-growing crop may sometimes be harvested upon the same soil if the vines be plowed under as soon as the crop has been harvested, or the ground may be sown to a clover cover-crop to be plowed under the following spring.

It will be necessary to clean out, fertilize and cultivate the rows if retained for a second crop. Some growers use a mowing machine and as soon as the leaves are sufficiently dry burn over the field during a wind blowing in the direction of the rows. There is some danger of injury to the crowns of the plants unless great care be taken. The rows are narrowed down with plow, disc-harrow or cultivator to a width of from six to twelve inches, the soil thoroughly stirred and a heavy application of plant food, preferably well-rotted stable manure, applied broadcast and directly over the rows.

SPECIAL CULTURE.

Forcing strawberries in greenhouses.— The earliest runners should be rooted in small pots filled with rich soil, plunged alongside the rows and as soon as the pots become filled with roots, the plants should be taken up and shifted into six-inch pots and plunged in coal ashes in a cold frame. The plants should be ripened off in October and as soon as cold weather sets in should receive winter protection. They should be brought into the forcing-house in January or February and may be expected to produce ripe fruit in from eight to twelve weeks. The blossoms should be hand-pollinated and not more than from six to eight fruits matured per pot. After the fruit sets an occasional application of liquid from well-rotted cow manure may be found beneficial. A support for the berries should be provided.

Irrigation of strawberries.— A season seldom passes without the yield being reduced by a lack of moisture. Most of the growers have no special water supply or their land is unsuited to irrigation purposes. But few locations have natural advantages so that an abundant water supply may be cheaply applied to the land, either by diverting streams or by a system of pumping the water. An occasional grower may be found who has in operation some such system or who is using what is known as the "Skinner" system, which consists of parallel lines of pipes in which are inserted specially devised nozzles a short distance apart. A turning device enables one to direct and control the water distribution. All things considered, nearly all the strawberry growers of this State will find it more desirable to put special emphasis on efforts to secure a maximum amount of humus in the soil on account of its water-holding powers, and to conserve as much water as possible by thorough cultivation and by mulching.

PESTS AND THEIR CONTROL.

Spraying.— Few, if any, growers in this State make a practice of spraying strawberries. The rotation is so short that insects and diseases seldom cause serious injury. In some seasons, however, injuries may be lessened by thorough spraying with either bordeaux mixture or lime-sulphur for diseases and with an arsenical such as arsenate of lead if insects are present.

Insects.— White grubs. Nearly all growers are more or less familiar with these insects which live in the ground feeding on the roots and crowns of the strawberry plants. They are the larvæ of the "June bugs" and are most abundant in grass lands. There is no remedy except to avoid such land for strawberries. Fall plowing may destroy a few of the insects, but cannot be depended upon to prevent injury.

Leaf-roller. The name indicates the habit of the insect. It is

a small, brownish caterpillar which folds over one portion of the leaf and lives and feeds within the protecting fold. Spraying for the first brood must be made before the insect is protected within its folded leaf, using arsenate of lead three pounds to fifty gallons water. Mowing and burning the beds after fruiting will destroy many of the insects and if necessary a later arsenical spray may be found beneficial for the late brood.

Strawberry weevil. The eggs, which later hatch into small whitish grubs, are laid in the flower buds. The egg-laying beetle eats away part of the stem below the bud causing it to droop. The grubs feed on the pollen of the flower bud and on this account the imperfect-flowering kinds are not attacked by the insect. No satisfactory remedy can be given. Spraying will give but little relief as the insects feed within the buds and are thus protected from spray materials. In cases of severe infestation badly affected beds may be burned over after fruiting; clean culture should be given; neglected spots grown up to weeds, especially if adjacent to the strawberry bed, should be destroyed, as such places usually harbor the insects; and a quick rotation of crops grown.

Diseases.— Leaf-spot. This is the most serious disease of strawberries. Its presence is indicated by circular light-colored spots, bordered with red, on the leaves. Good air and soil drainage with selection of somewhat resistant varieties aid greatly in reducing the amount of injury. In severe cases it may be necessary to spray thoroughly with bordeaux mixture (3–3–50) as growth begins in the spring and again just before blossoming time; or in some seasons spray as soon as the old rows have been cleaned out after fruiting time. If necessary arsenate of lead 3 pounds to 50 gallons may be combined with any of these sprayings for insect troubles. A quick rotation tends to reduce injury both from diseases and insects.

Mildew.— A fungus disease affecting the leaves spreading over the surface as a dull whitish mold and causing them to curl. Some varieties are much more susceptible to this disease than others. Spraying with bordeaux mixture as recommended for leaf-spot will aid somewhat in holding this disease in check, but a spray of sulphide of potassium one ounce to two gallons water is usually more efficient.

FRUIT.

Picking and marketing.— The fruit must be picked and handled with care to arrive at its destination in good condition. The surface of the berries should not be bruised. The color should be well-developed over the entire surface on its arrival at the market, picking slightly greener for distant than for nearby markets. If picked when wet the fruit will not ship well. The hull or calyx should be attached to each berry. Some growers prefer to grade the fruit as it is picked, placing the inferior fruit by itself in boxes in the

picking stand which usually holds from four to eight baskets. The fruit is usually marketed in quart boxes which are put in crates of various sizes, the 32-quart crate being mostly in use.

Yields, costs and profits.— Productiveness is a variable factor depending on the variety, seasonable rainfall, temperature, character of soil, amount of available food either in manure or fertilizers, amount of humus in the soil, and the cultural treatment given. While the average yield is low, about 3000 quarts per acre, it may readily under favorable conditions reach 9000 quarts or more.

Costs are more difficult to determine than yields, on account of the questions involved, depending on value of land, cost of manure and fertilizers, amount of labor required not only to grow the crop but also to place it on the market, and on the business ability of the manager. It is estimated that the average cost of growing a 32-quart crate of berries and placing it on the market is in the neighborhood of $1.00 per crate.

Profits are more elusive than either yields or costs because all factors of both yields and costs must be considered and the selling price determined before the balance can be struck. While there are many variations and wide extremes, a fair profit appears to be about $1.00 per 32-quart crate, and the yield per acre would largely determine the amount of the profit.

LITERATURE.

Publications available on strawberries.— This Station makes no recommendation as to the best books on strawberries. The Biggle Berry Book, Small Fruit Culturist, Strawberry Culture, and Modern Strawberry Growing should be available at any of the large book houses. Nearly all the Experiment Stations issue from time to time information on this subject, which may be secured free of cost on application. The suggestions given in this circular are not full, specific directions. Details vary widely in different places and must be worked out by each grower to meet his own conditions.

VARIETIES RECOMMENDED FOR TRIAL.

The following list of varieties is suggestive. All will not succeed equally well in any place, and some will be failures. The list, however, includes only those that have made a good record at this Station during recent years, including both older and newer varieties, and which appear to be worthy of trial:

EARLY:

Black Beauty.— Imp.; glossy, dark red berries; high quality.
Dunlap.— Per.; standard, excellent but size decreases in late pickings.
Golden Gate.— Semi-Per.; very productive; many qualities to commend it.
Grand Marie.— Per., bloom late; berries long, large, ship well.
Indiana.— Per., large, retain size, dark, glossy red; one of the best.
Monroe.— Per., berries large, light red; bloom early.
Parcell Early.— Per., Dunlap type but blooms and ripens earlier.

MIDSEASON:

Abington.— Per.; early midseason; very productive; light red.
Amanda.— Per.; many plants; very productive; berries wedge-shape
Baltimore.— Per.; excellent shipper; good in size and quality.
Barrymore.— Per.; very productive; quality very good; one of the best.
Chesapeake.— Per.; few runners, berries glossy red; very choice.
Clara.— Per.; attractive dark red, large; quality high.
German Beauty.— Per.; large, glossy, dark red; very good.
Glen Mary.— Per.; standard; does not succeed on all soils.
Good Luck.— Per.; very productive, bloom late; firm; sprightly acid.
Goodwin.— Per.; plants few, dark green; berries dark red; very high quality.
Kittie Rice.— Imp.; a mild berry ranking high in quality.
Marshall.— Per.; standard for excellence; dark red; medium yield.
New Discovery.— Per.; plants vigorous, very productive; fruit most attractive in appearance.
Phoenix.— Semi-Per.; fruit of largest size, irregular shape; quality high.
Prolific.— Per.; productive, large, bright scarlet; one of the best.
Sample.— Imp.; standard; excellent color; long season.
Sherman.— Imp.; dark green foliage; good quality for a tart berry.

LATE:

Brandywine.— Per.; standard; foliage good; fruit large, dark red.
Columbia.— Imp.; many runners; very productive; large, light red.
Granger.— Imp.; long-conic, attractive bright red; quality very good.
Jessie.— Per.; standard; one of the best late varieties but partial to soils.
Mascot.— Per.; flowers large; berries of largest size, irregular shape; very good quality.
Rough Rider.— Per.; many desirable qualities; one of the best.
Stevens Late Champion.— Per.; berries firm, sprightly, high quality.

CURRANTS.*

O. M. TAYLOR.

Location and soil.— Currants are by nature northern plants. They do not thrive in the heat of the South and are there of no commercial importance, but are found growing successfully only in cooler climates and are uninjured in low temperatures which are fatal to many other plants. They thrive best in the North Temperate regions, in northern exposures, on cool, moist, retentive soils, and under some conditions, in the partial shade of orchard trees or vineyards. For home use, some fruit may be obtained on almost any soil. Under commercial conditions, however, the heavier well-drained clay loams should be selected, avoiding as far as possible those of a light sandy nature.

Preparation of soil.— As the bushes occupy the ground for a number of years considerable care should be given to preparation of soil. It should be well drained. Currants dislike wet feet and will not thrive if too much water remains in the soil for any length of time. Quack grass, if present, should be eradicated before setting the plants as it is difficult to keep down if intermingled with the currant roots. The soil should be well stocked with humus before setting the plants, either by plowing under heavy applications of stable manure or a cover crop, preferably a clover sod. Deep plowing will not only cause the plants to root more deeply but will conserve moisture, especially if the following season be dry. Thorough cultivation should be given to make the soil fine and mellow before setting the plants.

Manures and fertilizers.— As with strawberries, there is but little danger of too much plant food in the soil. Currants are rank feeders and to secure maximum yields a rich soil and liberal applications of available food are essential. The roots extend but a short distance and their food must be within reach. Stable manure is one of the best fertilizers, and should be applied preferably in November, during the winter or very early in the spring before growth starts so that the crop of fruit may receive the maximum benefit from the fertilizer before the berries reach maturity in July. On most soils there is but little danger of too rank a growth or a decrease in productiveness from an excess of nitrogenous fertilizer.

It may be necessary at times to use commercial fertilizer, but the kind and amount to use depend on conditions. The plant-food requirements of the currant are not materially different from those of the strawberry or other fruits; and the supplements needed on any soil are best determined by individual experiments with nitrogen,

* Reprint of Circular No. 32, November 20.

phosphoric acid and potash. Applications should be liberal and checks should be left so that benefits, if any, may be apparent. The following amounts are only suggestive: Two to three hundred pounds per acre of nitrate of soda or three to six hundred pounds dried blood to stimulate growth, applied as soon as the leaves have unfolded; one ton of wood-ashes or two to three hundred pounds muriate of potash; six to seven hundred pounds acid phosphate; all to be applied early in the spring. If the soil is already well supplied with any one of these forms of plant food it is useless to make additional applications of that kind. The fertilizers will not take the place of humus.

Propagation.— Nurserymen are usually well supplied with plants to fill orders, yet the varieties are easily propagated and the fruit-grower can often raise his own plants to advantage. In the fall, as soon as the leaves have dropped, hard wood cuttings from six to ten inches long, the longer cuttings being preferred for dry soils, are made from well-ripened wood of one season's growth; they may be planted at once in nursery rows or tied in bundles and buried butt end up in moist sand or moss to callus for a few weeks, after which they are planted or they may remain in the sand until early spring. The cuttings are planted deeply leaving but one or two buds above the surface, placing them from four to six inches apart in the row, and compacting the soil firmly about the cuttings. If fall-planted, they must receive winter protection either with a slight back furrow of earth directly over the row or with a covering of coarse stable manure or straw applied after the ground freezes, to prevent heaving from the action of frost. They are left in nursery rows from one to two years, receiving thorough cultivation whenever necessary. A few plants are occasionally propagated from layers — the canes being bent down and a portion covered with earth, leaving the tips exposed. Roots soon develop from the covered cane which may then be separated from the main bush and planted in a permanent location.

Selection of varieties.— A variety may succeed in one place and yet be undesirable in another locality. Under different environments and under unlike surroundings the same variety may change both in plant- and fruit-habits. As with strawberries, adaptation should be determined before planting extensively in the commercial plantation. But few of the thirty-three varieties growing on the grounds of this Station have any commercial value. We may determine what varieties to set, first, by observation of the kinds doing well in the immediate locality under apparently similar conditions and, second, by a trial of a few plants before setting extensively. No variety has all the qualities equally developed that go to make perfection. The newer, most promising kinds should be tested in a small way and their value determined. Occasionally one may be found superior to the older varieties.

The commercial culture of currants in this State is practically confined to but one species, *Ribes rubrum*, to which class all the reds and whites belong, although there are a few varieties grown of the black currant, *Ribes nigrum*. Varieties of the reds are of most commercial value, largely on account of their fine jelly-making properties. The whites make a jelly unattrative in appearance and as a rule the berries are not very good shippers. Many people dislike the peculiar flavor of the black currant although this may largely be overcome by putting the berries in scalding water for a few minutes and then cooking in fresh water. They are esteemed by some both for dessert and for medicinal purposes.

Selection of plants.— The age of the plant is of less importance than its condition. Either one or two-year-old plants may be used. If the growing season has been favorable some plants will be vigorous and well-grown as yearlings and are then preferred to older stock. Many plants, however, do not make much growth the first year and these should be grown a second year before being moved to the permanent bed. Inferior plants should not be set even if the purchase price be low. The best stock obtainable should be used.

Time of setting.— Plants may be set either in fall or spring. The buds, however, start into growth very early in the spring and on this account fall planting is preferable. If set in the spring the work should be done as early as possible.

Setting the plants.— After the plants have been dug they should be trimmed for setting. The amount of pruning depends on the age and condition of the plants — usually cutting back the top and shortening in the roots in accordance with the amount of growth. After a thorough preparation of the soil the land should be marked both ways, the distance apart of rows and plants depending on the richness of the soil and the habit of growth of the variety. The usual distance for most varieties is six by four or five feet, the wider distance being preferable. The plants are to remain in position for several years and should not be crowded. Six by six feet is none too far for some varieties. Black currants should be given more room than reds on account of their vigor. After the ground has been marked both ways the plants may be set rapidly by plowing a deep furrow one way and setting the plants at the intersection of furrow and mark. The crown of the plant should not be above the surface but rather at a level with or preferably a trifle below the surface of the ground. The soil should be firmly pressed about the fibrous roots.

Cultivation.— The root system of currants is shallow, hence cultivation should not be deep near the plants. Growth begins early, requiring early, thorough and frequent working of the soil both to conserve moisture and to make available plant food. For family use currants succeed fairly well if thoroughly mulched with coal ashes,

straw or with coarse stable manure. In commercial plantations such mulching will not take the place of cultivation. On heavy clay soils plowing may be necessary at times, yet it must be done with care or severe injury may be done to the shallow roots. After the crop has been harvested the ground should be thoroughly worked over and the soil put in fine condition for a cover-crop to be sown in late July or early August, using about fifteen pounds clover seed per acre or twenty-five pounds vetch or about one bushel of oats or barley. Mixtures of the seed are sometimes used to advantage. A hoed crop may be grown between the plants the first year.

Pruning.— Systematic pruning is essential to improve the size of the fruit and to renew the old and weak wood. The bush-form is preferable to the tree-form. The best fruit is borne at the base of one-year-old shoots and on one-year-old spurs which develop from the two- and three-year-old wood. Most of the wood over three years old should be cut out, and only enough of the yearling wood left to maintain a yearly supply of the younger wood. From five to eight canes, well distributed to avoid crowding, are sufficient per bush depending upon richness of soil and on the variety. Most bushes are left too thick. An upright yet open habit of growth should be encouraged. It is usually unnecessary to head back the new canes but it is often an advantage to cut back very vigorous shoots. Pruning may be done any time after the leaves have dropped in the fall, or during the winter or in early spring before growth starts. Black currants are borne on wood of the previous year.

Pollination.— The few experiments that have been made indicate that the currant is usually self-fertile. It is generally an advantage to grow more than one variety to extend the picking season and any possible advantage through cross-pollination may then be secured. The cause of cluster ends failing to set fruit is not well understood.

Spraying.— Spraying is usually necessary each year. Disease or insect pests are to be expected. The material used and the time and manner of application depend on the kind of insect or disease; some are very difficult to combat. Foliage must be protected against their ravages or the present year's crop may be greatly decreased and the bushes left in poor condition to develop fruit-buds for the crop of the following year. The bushes should be sprayed with a combined insecticide and fungicide soon after the fruit begins to swell, and again, after the fruit has been harvested, with a fungicide.

Insects.— Currant worm. Usually present each year attacking and eating the foliage; eggs are laid on underside of leaves; two broods a year, each having a long season. The worms may be easily killed with an arsenical spray such as arsenate of lead, three pounds to fifty gallons, applied as soon as they make their appearance soon after the fruit begins to swell. This spray should be combined with a fungicide, either bordeaux mixture, 3–3–50 formula,

or lime-sulphur 1 to 40. Powdered hellebore is sometimes used at the rate of a teaspoonful to a gallon of water.

Currant borer. The insect eats a burrow along the center of the cane, and remains in this tunnel over winter. The infested canes should be cut out and burned during the winter or early spring. Spraying is useless.

San José scale. Too well known to require a description. Should receive the same dormant treatment as other fruits — lime-sulphur 1 to 8, or one of the oil sprays.

Currant plant-louse. Many small lice found on the under surface of the leaves in midsummer causing them to look blistered and reddish on the upper surface. They are sucking insects. Whale oil soap, 1 pound to 5 gallons of water or kerosene emulsion, applied to the underside of the foliage will kill all that are hit with the mixture.

Diseases. — Leaf-spot. A fungus disease causing a brown spotting of the foliage and later death of the affected parts, the leaves often dropping prematurely. Remedy: lime-sulphur, 1 to 40, or bordeaux mixture, 3–3–50, applied at time of spraying for worms and again after harvest.

Cane-blight. A fungus disease quite destructive in the Hudson Valley. One or more canes die during the summer, or the death of the entire bush follows. No satisfactory remedy.

Hardiness.— Currants are hardy plants and will endure low temperatures without injury. They are liable to suffer more from heat than from cold. Occasionally insects or diseases may so weaken the plant in summer as to cause injury from cold during winter.

Duration of plantations.— The life of currant bushes depends on the care given, on the variety, and also on the soil. Under ordinary conditions they cannot be expected to produce profitable crops for more than eight or ten years although some fields may be held for a longer period. It is desirable, however, to plan for a new bed about every ten years depending on conditions. Old bushes may often be rejuvenated by cutting off all the canes close to the ground and giving a liberal application of stable manure.

Yields, costs and profits.— Productiveness depends on variety, rainfall, soil, plant food and cultural treatment. The yield may vary from 50 to 250 bushels per acre with an average of from 100 to 150 bushels annually, and is influenced by the distance of planting. Some fruit will be secured the third year but a full crop will not be produced until the fourth year. Black currants usually yield slightly less than the reds.

Costs are difficult to determine, depending on value of land, cost of manure and fertilizer, amount of labor required both to grow and to market the crop, and the character of the market. Mr. Samuel Fraser, Geneseo, N. Y., reports that the cost of growing and selling a three-ton crop of currants is in the neighborhood of $200 per acre.

Profits vary greatly from year to year depending on all of the factors involved in yields and costs and also on the selling price. The price received usually varies from four to eight cents per pound, averaging around five cents, depending on the character of the market. Most of the fruit goes to canning and jelly factories. Under some conditions an average profit of $100 per acre may be expected. In other cases it may vary one way or the other from that figure.

Picking and marketing the fruit.— The fruit must be picked and handled with care to arrive at its destination in good condition. The berries should be dry when harvested and not over-ripe. The stems should be severed from the bushes, care being taken not to pull off or injure berries. Some varieties are much more easily picked than others on account of the clear space of stem at the base of the clusters. Fruit may be picked greener for distant markets than for nearby markets, and slightly greener for jelly than for canning, a few green berries showing on each cluster. The season of harvest is comparatively long. Currants are usually marketed in quart baskets or in grape baskets and are mostly sold by the pound. The smaller baskets are placed in crates of various sizes similar to strawberries, the average sized crate holding 32 quarts.

Publications available on currants.— This Station makes no recommendations as to the best books on currants. They are very few. The subject is treated in "Bush Fruits", and "Small Fruit Culturist" which should be available at any of the large book houses. Nearly all the Experiment Stations issue from time to time information on this subject which may be secured free of cost on application. The suggestions in this circular are not full directions. Details vary widely in different places and must be worked out by each grower to meet his own conditions.

Varieties recommended for trial.— The following list of varieties is suggestive. The kinds will not all succeed equally well in every place. Some will be failures. The list, however, includes only those varieties that have made a good record at this Station during recent years including older and newer varieties which appear worthy of trial.

Red Currants.

Chautauqua.—Vigorous, productive; clusters long; berries large; picks easily.

Cherry.— Large; clusters short; productive; standard.

Diploma.— Vigorous, upright; light red, semi-transparent berries.

Fay.— Sprawling habit; large; medium productive.

Filler.— Productive; bunches short; berries large.

Perfection.— Bush more upright than Fay, medium in vigor; large berries, high quality.

Red Cross.— Large; milder and slightly later than Cherry.

Red Dutch.— Growth good; sprightly acid; dark red; medium size.

Ruby.— Mild-flavored; desirable for home use.

Wilder.— Good late variety; vigorous; fruit large; long season; standard.

White Currants.

White Imperial.— Mild, high quality for dessert; pleasant flavor.
White Grape.— Large; attractive color; medium quality.

Black Currants.

Champion.— Mild, nearly sweet.
Prince of Wales.— Very productive, mild, sweet; vigorous.
Boskoop Giant.— Very promising; large berries, long clusters; productive; one of the best.

REPORT

ON

INSPECTION WORK.

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[1] Resigned March 26.
[2] Resigned December 7.
[3] Appointed February 7, resigned November 15.
[4] Appointed May 1.

REPORT ON INSPECTION WORK.

SOME FACTS ABOUT COMMERCIAL FERTILIZERS IN NEW YORK STATE*

L. L. VAN SLYKE.

SUMMARY

I. COMPOSITION OF FERTILIZERS AND COST OF PLANT-FOOD CONSTITUENTS.

(1) In the purchase of complete fertilizers, plant-food constituents cost least in high-grade mixtures and most in low-grade. (2) The tendency among farmers at the present time appears to be in the direction of purchasing more high-grade mixtures. (3) In complete fertilizers as well as in other mixtures and unmixed materials, the variation in selling price is often wholly out of proportion to the amount of plant-food present. (4) Nitrogen costs least in nitrate of soda; in organic materials it costs least in dried blood, tankage and fish scrap. (5) Phosphoric acid in quickly available form costs least in the form of acid phosphate; in organic materials it costs least in the form of tankage. (6) Potash costs least in muriate of potash. (7) Plant-foods can be purchased generally in unmixed materials at less cost than in mixtures. (7) In dried commercial sheep manure plant-food costs more than in any other form examined.

II. RELATION OF GUARANTEED TO ACTUAL COMPOSITION IN FERTILIZERS.

(1) In the case of each constituent of complete fertilizers, the number of samples showing results above the guaranteed statement of composition is much larger than the number below. (2) The largest number below guaranty is in case of nitrogen (166 samples), followed by potash (151 samples), while the smallest number (112) below is in case of phosphoric acid. (3) Balancing all the cases of excess and deficiency in the 614 samples of complete fertilizers, we find that there is an average excess of 0.08 per ct. of nitrogen, 0.44 per ct. of available phosphoric acid and 0.34 per ct. of potash. (4) In the case of fertilizer materials and mixtures other than complete fertilizers, the average percentage found is above that guaranteed in all cases excepting fish scrap and calcium (lime) carbonate. (5) In such

* Reprint of Bulletin No. 392, December; for Popular Edition see p. 959.

materials as sodium nitrate, potassium sulphate, kainit, basic slag phosphate, rock-phosphate (floats), and mixtures of bone and potash, the number of samples below guaranty is within reasonable limits and amounts. (6) In materials such as acid phosphate, potassium chloride (muriate), bone, tankage, sheep manure, mixtures of acid phosphate and potash, wood-ashes and compounds containing calcium, a larger proportion of samples is below guaranty than is desirable and in some cases the amount of plant-food below guaranty is serious.

III. SOME DEFECTS IN THE PRESENT FERTILIZER LAW.

(1) Under the present fertilizer law, 27 samples of complete fertilizers and 7 samples of fertilizing material are violations among the samples analyzed in 1914, about one-third the number of violations there would be under the provisions of the law in force previous to 1910. (2) The present law permits absolute exemption of deficiencies of plant-food amounting in some cases to a value of $5 or more per ton. (3) In the case of high-grade fertilizers and especially of fertilizing materials, the present law offers an opportunity for cheating farmers with impunity. (4) The present law needs amendment in order to limit more carefully the amounts of deficiencies that are absolutely exempt.

INTRODUCTION.

The farmers of New York State expend for plant-foods in the form of commercial fertilizers about five million dollars a year. While many dairy farmers depend largely or wholly upon farm-produced manures as the source of plant-food, all who most profitably and continuously raise cereals, hay and forage crops, potatoes, fruits, flowers, ornamental plants, nursery stock, garden crops, root crops, hops, tobacco, crops under glass, etc., are compelled to use liberal quantities of commercial fertilizers. The rates of application vary with the character of the agriculture carried on in different sections of the State, the largest amounts being used in the growth of market-garden crops.

In view of the large expenditures, it becomes a matter of economic importance to the many farmers who use commercial plant-food materials to exercise the best business judgment possible in the purchase of their plant-foods. It is a prominent fact that a very large proportion of the commercial fertilizers used in New York State is in the

form of so-called complete fertilizers, that is, mixtures containing compounds of nitrogen, phosphorus and potassium. As we shall point out later these vary greatly in composition, price and the cost of plant-food.

It is the principal object of this bulletin to call attention to such differences in cost of plant-foods as we have actually found to exist in the case of various commercial fertilizers sold in this State during 1914. There are certain important facts which should be made known to purchasers of commercial fertilizers in order that in the future they may buy their needed plant-foods more economically than they have been doing.

In addition to the subject of cost of plant-foods, we shall discuss the composition of commercial fertilizers, the relation of guaranteed to actual composition, and some points in relation to the present laws governing the sale of fertilizers.

The analyses of fertilizers contained in Bulletin No. 390 of this Station are used as the basis of our discussion. Through the courtesy of the Commissioner of Agriculture, Hon. Calvin J. Huson, it was possible to obtain retail prices paid by farmers for fertilizers.

The following outline statement gives a classification of fertilizers, the analyses of which are contained in Bulletin No. 390.

Kind of fertilizer or material.	Number of samples analyzed.
Complete fertilizers	614
Mixtures of acid phosphate and potash salts	117
Acid phosphate	57
Sodium nitrate	39
Bone materials	34
Potassium chloride (muriate of potash)	27
Lime compounds	25
Tankage	20
Dried blood	14
Kainit	11
Sheep manure, dried	9
Potassium sulphate	5
Basic slag	5
Mixtures of bone and potash salts	4
Mixtures of compounds of calcium (lime), phosphorus and potassium	4
Wood-ashes	4
Rock-phosphate	4
Ground fish	3
Dissolved bone	1
Ammonium sulphate	1
Miscellaneous mixtures	6
Total	1,004

I. COMPOSITION OF FERTILIZERS AND COST OF PLANT-FOOD CONSTITUENTS.

For the purpose of the study presented in the following pages, we have made an arbitrary division of complete fertilizers into four separate classes, based upon their commercial valuation, that is, the price at which the separate unmixed materials could be purchased for cash at retail at the seaboard. Our classification is as follows:

Class 1. *Low-grade fertilizers*, those having a commercial valuation of less than $16 a ton.

Class 2. *Medium-grade fertilizers*, those having a commercial valuation greater than $16 and less than $20 a ton.

Class 3. *Medium high-grade fertilizers*, those having a commercial valuation greater than $20 and less than $25 a ton.

Class 4. *High-grade fertilizers*, those having a commercial valuation greater than $25 a ton.

We will now make a comparative study of these four classes of complete fertilizers from the following points of view:

1. Distribution of fertilizers among the different classes.
2. Composition of fertilizers in different classes.
3. Relation of selling price to commercial valuation in different classes.
4. Cost of one pound of plant-food in different classes.

DISTRIBUTION OF FERTILIZERS AMONG DIFFERENT CLASSES.

Taking the 614 complete fertilizers whose analyses are given in Bulletin No. 390, we find they are distributed among the four different classes as follows:

Class 1, low-grade	126, or 20.5 per ct. of all.
Class 2, medium-grade	172, or 28 per ct. of all.
Class 3, medium high-grade	156, or 25.4 per ct. of all.
Class 4, high-grade	160, or 26.1 per ct. of all.

On the basis of these data, nearly 50 per ct. of the brands of complete fertilizers sold in this State during 1914 were medium or low-grade in character. Since, however, much larger quantities of these grades of fertilizers are sold than of the higher grades, the figures given above would be considerably changed if we knew the amounts of each class purchased by farmers. Comparing these figures with some obtained in 1902, it is noticeable that the proportion of medium high-grade

and high-grade brands of fertilizers is considerably greater now than then, while the reverse is true of the lower grades. The figures for 1902 are as follows: Low-grade 25 per ct.; medium grade, 34 per ct.; medium high-grade, 24 per ct.; high-grade, 17 per ct. It is thus seen that while the custom has been to purchase largely complete fertilizers of the lower grades, the tendency is now in the direction of the higher grades.

COMPOSITION OF COMPLETE FERTILIZERS IN DIFFERENT CLASSES.

If we compare the four different classes of complete fertilizers in respect to the average amounts of nitrogen, available phosphoric acid, and potash contained in them, we have the following results in tabulated form:

Table I.— Composition of Different Grades of Fertilizers.

Class of Fertilizers.	In 100 Pounds of Fertilizer.			
	Pounds of nitrogen.	Pounds of available phosphoric acid.	Pounds of potash.	Pounds of total plant-food.
Low-grade	1.01	8.12	3.22	12.35
Medium-grade	1.61	8.28	4.67	14.56
Medium high-grade	2.09	8.00	7.94	18.03
High-grade	3.70	7.78	7.89	19.37

In the last column, under the heading "pounds of total plant-food," we give the sum of the amounts of nitrogen, available phosphoric acid and potash. We notice the following points in connection with this table:

(1) The percentage of phosphoric acid does not vary greatly in the different classes of fertilizers, being about 8 per ct.

(2) The percentage of nitrogen and of potash increases in the higher grades, though it is to be noted that the amount of potash in the two highest grades is essentially the same.

(3) The total amount of plant-food in 100 pounds of fertilizer increases in the higher grades, this increase being due to increase of nitrogen and potash.

(4) Representing the amount of nitrogen in each class as 1, we have

the following proportions of available phosphoric acid and potash in the different grades:

CLASS OF FERTILIZERS.	Nitrogen.	Available phosphoric acid.	Potash.
Low-grade	1	8	3.2
Medium-grade	1	5	2.9
Medium high-grade	1	3.8	3.8
High-grade	1	2.1	2.1

This form of statement clearly brings out the fact that fertilizers of different grades differ not only in respect to the amounts of plant-food contained in them, but that the different elements of plant-food bear a different ratio to each other in the different grades. Thus, it is seen that, as the grade becomes higher, the proportion of phosphoric acid to nitrogen grows less, or, stated another way, the proportion of nitrogen to phosphoric acid increases. In low-grade fertilizers, the amount of phosphoric acid is 8 times as much as that of nitrogen, while in the high-grade class there is about twice as much. In the case of potash, the variation of the ratio of nitrogen to potash, while noticeable, is not as great as in the case of the ratio of nitrogen to phosphoric acid.

(5) The ratio of nitrogen, phosphoric acid and potash found in high-grade fertilizers approximates much more closely the ratio found in plants than does the ratio existing in the low-grade class.

RELATION OF SELLING PRICE TO COMMERCIAL VALUATION.

In the table below, we give the average actual selling price and the average commercial valuation in the case of each class of fertilizers, and also the excess of selling price over the commercial valuation. Since the commercial valuation represents the average retail price of the separate, unmixed materials contained in one ton of fertilizer at the seaboard, the excess of selling price above commercial valuation represents the cost of mixing, freight, profits and cost of business.

In making the commercial valuations, the prices given in Bulletin 390 on page 492 are used, except that the available phosphoric acid is valued at $4\frac{1}{4}$ cents a pound and the potash at $4\frac{1}{2}$ cents.

TABLE II.— SELLING PRICE AND COMMERCIAL VALUATION OF DIFFERENT GRADES OF FERTILIZERS.

	Low-grade.	Medium-grade.	Medium high-grade.	High-grade.
Selling price of one ton				
Lowest	$17.60	$19.00	$23.50	$21.00
Highest	30.00	45.00	55.00	52.00
Average	22.98	25.97	30.40	34.77
Commercial valuation of one ton				
Lowest	10.57	16.00	20.04	23.30
Highest	15.97	19.98	24.90	52.19
Average	13.74	17.52	22.10	28.15
Differences between selling price and commercial valuation				
Lowest	2.03	0.00	0.10	*4.79
Highest	16.24	23.00	27.42	18.65
Average	9.24	8.45	8.30	6.62

* Commercial valuation exceeds selling price.

An examination of the figures contained in this table suggests several points of interest, among which we will call attention to the following:

(1) We notice that the selling price for any one grade of fertilizers varies greatly. In addition it can be shown that the extremely high prices in each grade have little relation to the actual composition and plant-food value of the fertilizers. This can be shown by the following tabulated data, giving the selling price and commercial valuation for those particular samples which sold at the highest and lowest prices in each grade.

	LOW-GRADE.		MEDIUM-GRADE.		MEDIUM HIGH-GRADE.		HIGH-GRADE.	
	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.
Selling price of one ton	$30.00	$17.60	$45.00	$19.00	$55.00	$23.50	$52.00	$21.00
Commercial valuation of one ton	13.76	14.45	16.59	19.00	23.10	23.40	39.36	25.79

In the low-grade class, the difference between the lowest and highest selling prices ($17.60 and $30) is $12.40, while the difference in the value of the plant-food is only 69 cents; in fact, the fertilizer selling at $30 actually contains less plant-food than the one selling at $17.60. In the medium-grade class, the difference between the highest and lowest selling prices is $26, while the difference in value of plant-food is only $2.41, and, moreover, the one selling for the lowest price ($19) contains plant-food worth $2.41 more than the one selling for $45. In the medium high-grade class, a similar condition exists. The difference between the highest and lowest selling prices ($55 and $23.50), is $31.50, while the difference in commercial valuation or plant-food value is only 30 cents; in other words, the fertilizer selling at $55 contains plant-food worth 30 cents less than the fertilizer selling for $23.50. In the high-grade class, a somewhat similar condition exists but the difference in the plant-food values is much more nearly in proportion to the selling prices.

(2) The average excess of selling price over commercial valuation is greatest in the low-grade class and decreases with each higher grade. Thus, the figures for the four grades, beginning with the lowest, (Table II) are $9.24, $8.45, $8.30 and $6.62; in other words, the high-grade fertilizers sell, on an average, nearer to their actual plant-food value than do those of lower grade.

COST OF ONE POUND OF PLANT-FOOD IN DIFFERENT CLASSES OF FERTILIZERS.

The difference in cost of plant-food in fertilizers of different grades can best be brought out by showing the cost of one pound of plant-food as purchased by the consumer. In the following table, we state the lowest, highest and average cost of one pound of nitrogen, of available phosphoric acid, and of potash in complete fertilizers as actually purchased by consumers in 1914.

These figures are obtained by dividing the selling price by the commercial valuation and then multiplying the result by the price per pound used in making up the valuation for each constituent.

These figures show, in general, that the higher the grade of fertilizer, the lower is the cost of each pound of plant-food. The cost of one pound of plant-food, whether nitrogen, phosphoric acid, or potash, is greatest in low-grade and least in high-grade fertilizers. If we take

Table III.— Cost of One Pound of Plant-Food in Different Grades of Fertilizers.

	Low-grade.	Medium-grade.	Medium high-grade.	High-grade.
	Cents.	*Cents.*	*Cents.*	*Cents.*
Cost of one pound of Nitrogen				
Lowest	22.0	19.5	19.5	15.8
Highest	42.5	45.8	44.2	33.0
Average	32.5	28.9	26.9	24.2
Cost of one pound of Available Phosphoric Acid				
Lowest	4.8	4.2	4.2	3.4
Highest	9.3	10.0	9.6	7.2
Average	7.1	6.3	5.9	5.3
Cost of one pound of Potash				
Lowest	5.1	4.5	4.5	3.6
Highest	9.8	10.6	9.7	7.7
Average	7.5	6.7	6.2	5.6

the average of all the complete fertilizers analyzed, we find the price of one pound of nitrogen is 27 cents, of phosphoric acid, 5.9 cents and of potash, 6.2 cents.

THE COMPOSITION OF MIXTURES CONTAINING PHOSPHORIC ACID AND POTASH AND THE COST OF PLANT-FOOD.

Considerable quantities of commercial fertilizers are sold in the form of mixtures containing dissolved phosphate rock (acid phosphate) and muriate of potash, under a great variety of names, such as alkaline bone, alkaline bone and potash, akaline dissolved bone, alkaline manure, alkaline phosphate, akaline superphosphate, bone and potash, dissolved bone and potash, dissolved phosphate and potash, phospho-potasso, potash mixture, potash and soluble phosphate, superphosphate with potash, and many other special names that have no reference to the composition of the mixtures. It should be stated in passing that the use of the word "alkaline" in connection with such mixtures is entirely misapplied and misleading and the same is true of the use of the word "bone" or "dissolved bone."

For some years these mixtures of acid phosphate and muriate of potash have been popular with many farmers and their use has been increasing extensively. This can be readily explained by the fact that, since they contain no nitrogen, they can be sold at prices which

look cheap in comparison with the cost of complete fertilizers; and many farmers still consider cheapness only, and not composition, in purchasing fertilizers.

Of the 1000 fertilizers analyzed, 117, or nearly 12 per ct., are those containing phosphoric acid and potash. In the table following, we give data that show the composition, selling price, commercial valuation, and the cost of one pound of phosphoric acid and of potash.

TABLE IV.— AMOUNT AND COST OF PHOSPHORIC ACID AND POTASH IN SPECIAL MIXTURES.

	Highest.	Lowest.	Average.
Pounds of phosphoric acid in 100 pounds	13.35	6.50	10.60
Pounds of potash in 100 pounds	10.90	2.00	5.60
Selling price of one ton	$28.00	$14.00	$18.57
Commercial valuation of one ton	17.16	10.19	14.05
Cost of 1 pound of phosphoric acid	9.1 cents	4.3 cents	5.6 cents
Cost of 1 pound of potash	9.6 cents	4.6 cents	5.9 cents

(1) From the data in the foregoing table, it is obvious that in respect to cost of plant-food, the lowest prices are about the same as those found in medium high-grade complete fertilizers and the same is true of the highest prices. Taking the average prices of phosphoric acid (5.6 cents) and of potash (5.9 cents), they are somewhat higher than those found in complete high-grade mixtures and a little lower than those found in complete medium high-grade mixtures. Stated in another way, the cost of phosphoric acid and potash in mixtures of acid phosphate and muriate of potash averages less than in the different grades of complete fertilizers except high-grade fertilizers.

(2) The selling prices of mixtures of acid phosphate and potash salts are subject to much wider variations than is justified by variation in composition. For example, one such mixture, containing 10.51 per ct. of phosphoric acid and 7.77 per ct. of potash, was sold for $16.20, while another, containing 9.88 per ct. of phosphoric acid and 2 per ct. of potash was sold for $22.

COMPOSITION OF BONE AND POTASH MIXTURES AND COST OF PLANT-FOOD.

A few mixtures are found in the market containing bone-meal and potash salts. Several samples were analyzed.

TABLE V.— AMOUNT AND COST OF NITROGEN, PHOSPHORIC ACID AND POTASH IN BONE AND POTASH MIXTURES.

	Highest.	Lowest.	Average.
Pounds of nitrogen in 100 pounds	2.88	2.56	2.71
Pounds of total phosphoric acid in 100 pounds	17.60	4.33	13.11
Pounds of potash in 100 pounds	7.64	2.81	5.10
Selling price of one ton	$50.00	$37.00	$40.25
Commercial valuation of one ton	29.63	17.00	25.75
Cost of one pound of nitrogen	63.2 cents	27.1 cents	33.5 cents
Cost of one pound of phosphoric acid	11.8 cents	5.0 cents	6.2 cents
Cost of one pound of potash	12.5 cents	5.3 cents	6.7 cents

The cost of plant-food constituents is high in comparison with their cost in complete fertilizers of medium high grade. The cost of nitrogen and phosphoric acid is also high in comparison with their cost in bone-meal and in tankage. The variation in selling price is much greater than is justified by the variation in the amount of plant-food contained in the different samples. In connection with the cost of phosphoric acid in comparison with the available phosphoric acid of ordinary complete fertilizers, it must be kept in mind that the phosphoric acid of bone is less quickly available than in case of the phosphoric acid supplied by acid phosphate.

AMOUNT AND COST OF PLANT-FOOD IN ACID PHOSPHATES.

Most of the soluble phosphoric acid in the market is acid phosphate made from phosphate rock by treatment with sulphuric acid. Until quite recently it was the prevailing custom to give misleading names to this material such as "dissolved bone," "soluble bone," etc. It is therefore interesting to observe that of the 57 samples of acid phosphate given in Bulletin No. 390, not a single one is given a brand name containing the word "bone." In only two cases are the brand names such as to give no indication of the composition of the material. The results of our work are given in the following tabulated form:

TABLE VI.— AMOUNT AND COST OF PHOSPHORIC ACID IN ACID PHOSPHATE.

	Highest.	Lowest.	Average.
Pounds of phosphoric acid in 100 pounds	17.21	11.65	14.65
Selling price of one ton	$22.00	$9.97	14.50
Commercial valuation of one ton	14.84	10.21	12.45
Cost of one pound of phosphoric acid	8.3 cents	3.5 cents	4.95 cents

These figures show that, on an average, the available phosphoric acid costs less in the form of acid phosphate than in mixtures. It is difficult to conceive of conditions that would justify such an excessive price as $22 a ton for acid phosphate. It is obvious that the selling price varies much more than is justified by the variation of compositions.

AMOUNT AND COST OF PLANT-FOODS IN BONE-MEAL.

The following table gives the essential data in the case of 34 samples of bone-meal, collected in this State during the spring and summer of 1914.

TABLE VII.— AMOUNT AND COST OF NITROGEN AND PHOSPHORIC ACID IN BONE-MEALS.

	Highest.	Lowest.	Average.
Pounds of nitrogen in 100 pounds	4.21	2.02	3.12
Pounds of phosphoric acid in 100 pounds	27.68	15.82	23.33
Selling price of one ton	$50.00	$26.50	$36.60
Commercial valuation of one ton	36.86	21.60	32.08
Cost of one pound of nitrogen	36.1 cents	17.2 cents	24.5 cents
Cost of one pound of phosphoric acid	6.7 cents	3.2 cents	4.6 cents

The cost of nitrogen in bone-meal is about the same as in high-grade complete fertilizers. The cost of phosphoric acid is less than in complete fertilizers, even high-grade, and somewhat less than in acid phosphates, but it must be remembered that the phosphoric acid in bone-meals is considerably less quickly available than in the form of dissolved rock. When moderately slow action of phosphoric acid is desired, bone-meal may answer the purpose, but for rapid action one should use only forms that are readily soluble.

AMOUNT AND COST OF PLANT-FOODS IN TANKAGE.

Of 20 samples of tankage analyzed, 16 contain both nitrogen and phosphoric acid (bone and meat), while 4 contain nitrogen alone (meat). The important data regarding these samples are contained in the following table:

Table VIII.— Amount and Cost of Nitrogen and Phosphoric Acid in Tankage.

	Containing Nitrogen and Phosphoric Acid.			Containing only Nitrogen.		
	Highest.	Lowest.	Average.	Highest.	Lowest.	Average.
Pounds of nitrogen in 100 pounds	7.41	2.90	5.58	11.98	7.46	9.16
Pounds of phosphoric acid in 100 pounds	21.30	7.46	14.19	......	......	......
Selling price of one ton	$40.00	$23.00	$35.90	$46.00	$40.00	$43.00
Commercial valuation of one ton	38.89	31.95	35.35	53.91	35.57	41.72
Cost of one pound of nitrogen	26 cts.	13.4 cts.	22 cts.	28 cts.	20.7 cts.	24.4 cts
Cost of one pound of phosphoric acid	4.8 cts.	2.5 cts.	4.1 cts.	......	......	......

Nitrogen in meat tankage, containing no phosphoric acid, averages in price about the same as in case of high-grade complete fertilizers. In bone and meat tankage, the price of nitrogen averages somewhat less than in case of high-grade complete fertilizers. The phosphoric acid in tankage averages less than in bone-meal.

AMOUNT AND COST OF PLANT-FOOD IN DRIED BLOOD.

In 14 samples of dried blood the following data were obtained:

Table IX.— Amount and Cost of Nitrogen in Dried Blood.

	Highest.	Lowest.	Average.
Pounds of nitrogen in 100 pounds	13.63	9.05	10.75
Selling price of one ton	$61.95	$39.60	$50.78
Commercial valuation of one ton	61.34	40.73	48.38
Cost of one pound of nitrogen	23.8 cents	19.4 cents	21.6 cents

The average cost of nitrogen in dried blood is less even than in high-grade complete fertilizers, bone or tankage. In one case dried blood was retailed in small amounts at the rate of $100 a ton, while the commercial valuation was $57.33; in this case the nitrogen cost 39.2 cents a pound.

AMOUNT AND COST OF PLANT-FOOD IN NITRATE OF SODA.

We examined 39 samples of sodium nitrate with the following results:

TABLE X.— AMOUNT AND COST OF NITROGEN IN NITRATE OF SODA.

	Highest.	Lowest.	Average.
Pounds of nitrogen in 100 pounds	15.66	14.82	15.20
Selling price of one ton	$65.00	$48.00	$54.25
Commercial valuation of one ton	51.68	48.91	50.16
Cost of one pound of nitrogen	21 cents	16 cents	17.8 cents

These results show that nitrogen in nitrate of soda costs less than in any other form.

The extremes of selling prices are within narrower limits than in the case of other nitrogen-containing materials and mixtures.

AMOUNT AND COST OF PLANT-FOOD IN POTASSIUM SALTS.

We have analyzed 27 samples of muriate of potash (potassium chloride) 5 samples of sulphate of potash (potassium sulphate) and 11 samples of kainit. The composition of these materials and their cost are given in Table XI.

Potash costs least in muriate, most in sulphate and is intermediate in kainit. In any of these forms the average cost of potassium is less than in any of the mixtures containing potash salts with other plant-food materials.

At the present time, the cost of potash is about 15 cents a pound, owing to the war, and its use will be greatly limited until it can again be obtained freely.

Table XI.— Amount and Cost of Potash in Potassium Salts.

	Highest.	Lowest.	Average.
Pounds of potash in 100 pounds of muriate	53.50	45.01	49.80
Pounds of potash in 100 pounds of sulphate	52.70	48.64	50.17
Pounds of potash in 100 pounds of kainit	14.40	11.44	13.00
Selling price of one ton of muriate	$55.00	$39.00	$46.95
Commercial valuation of one ton of muriate	42.80	36.11	39.84
Selling price of one ton of sulphate	60.00	53.00	56.50
Commercial valuation of one ton of sulphate	52.70	48.64	50.17
Selling price of one ton of kainit	16.00	12.00	13.93
Commercial valuation of one ton of kainit	11.52	9.20	10.40
Cost of one pound of potash in muriate	5.6 cents	4 cents	4.7 cents
Cost of one pound of potash in sulphate	6 cents	5.5 cents	5.7 cents
Cost of one pound of potash in kainit	7 cents	4.4 cents	5.4 cents

COMPOSITION OF COMMERCIAL DRIED SHEEP MANURES AND COST OF PLANT-FOOD.

Within a few years past, the sale of dried sheep manure has been pushed vigorously and we obtained 9 samples for analysis. The following figures give the essential points of interest.

Table XII.— Amount and Cost of Nitrogen, Phosphoric Acid and Potash in Dried Sheep Manures.

	Highest.	Lowest.	Average.
Pounds of nitrogen in 100 pounds	2.53	1.99	2.23
Pounds of phosphoric acid in 100 pounds	2.61	0.66	1.56
Pounds of potash in 100 pounds	5.40	1.21	2.31
Selling price of one ton	$60.00	$24.00	$37.17
Commercial valuation of one ton	12.13	10.25	11.63
Cost of one pound of nitrogen	107 cents	43 cents	69 cents
Cost of one pound of phosphoric acid	20 cents	8 cents	10 cents
Cost of one pound of potash	69 cents	13 cents	16 cents

An examination of these figures indicates that (1) The dried sheep manures contain only small amounts of plant-food, averaging only 5 pounds in 100 pounds of material; (2) the selling price varies widely without reference to composition; and (3) the cost of one pound of nitrogen in these sheep manures is higher, much higher, than in any

other material coming under our examination; while the cost of phosphoric acid and potash is exceeded only in the case of wood-ashes.

COMPOSITION OF WOOD-ASHES AND COST OF PLANT-FOOD.

In 4 samples of wood-ashes, the following results were obtained.

TABLE XII.— AMOUNT AND COST OF PHOSPHORIC ACID AND POTASH IN WOOD-ASHES.

	Highest.	Lowest.	Average.
Pounds of potash in 100 pounds	5.52	3.26	3.95
Pounds of phosphoric acid in 100 pounds	1.70	0.50	1.10
Selling price of one ton	$30.00	$24.00	$27.00
Commercial valuation of one ton	5.52	3.85	4.72
Cost of one pound of potash	31 cents	29 cents	30 cents
Cost of one pound of phosphoric acid	21.7 cents	20.3 cents	21 cents

These figures show that the cost of potash and phosphoric acid averages higher than in any other form of commercial material in the market. If, however, the calcium carbonate present were given a value, the cost of the other constituents would be a little lower than the figures above. But it is a fair statement that one can not profitably use average wood-ashes as a source of plant-food when the price is over $10 a ton.

AMOUNT AND COST OF PLANT-FOOD IN FISH SCRAP.

The supply of fish-scrap is limited and the prices are higher than formerly. The following data apply to the few samples examined by us.

TABLE XIII.— AMOUNT AND COST OF NITROGEN AND PHOSPHORIC ACID IN FISH-SCRAP.

	Highest.	Lowest.	Average.
Pounds of nitrogen in 100 pounds	9.75	7.91	8.84
Pounds of phosphoric acid in 100 pounds	7.30	5.67	6.50
Selling price of one ton	$47.40	$43.00	$45.00
Commercial valuation of one ton	49.72	40.12	44.98
Cost of one pound of nitrogen	24 cents	21.4 cents	22.5 cents
Cost of one pound of phosphoric acid	4.3 cents	3.8 cents	4.1 cents

The cost of nitrogen and phosphoric acid averages less in fish-scrap than any other materials examined, excepting tankage containing meat and bone. One sample had been treated with acid and most of its phosphoric acid rendered soluble.

AMOUNT AND COST OF PLANT-FOOD IN BASIC SLAG PHOSPHATE.

The 5 samples examined enable us to give the following figures:

Table XIV.— Amount and Cost of Phosphoric Acid in Basic Slag Phosphate.

	Highest.	Lowest.	Average.
Pounds of phosphoric acid in 100 pounds	19.26	17.12	17.88
Selling price of one ton	$20.00	$16.50	$18.50
Commercial valuation of one ton	13.30	12.85	13.15
Cost of one pound of phosphoric acid	6.1 cents	5 cents	5.6 cents

The average cost of phosphoric acid in basic slag is somewhat more than that of the available phosphoric acid in high-grade complete fertilizers; it is the same as in mixtures of potash and acid phosphate; it is more than in acid phosphate, bone and tankage.

AMOUNT AND COST OF PLANT-FOOD IN GROUND ROCK PHOSPHATE.

Under certain conditions, the use of untreated ground rock phosphate, often called "floats," is coming into use in increasing amounts. The only quotation obtained is $13 a ton in the case of the 4 samples examined.

Table XV.— Amount and Cost of Phosphoric Acid in Ground Rock Phosphate.

	Highest.	Lowest.	Average.
Pounds of phosphoric acid in 100 pounds	33.54	29.68	31.52
Selling price of one ton	$13.00	$13.00	$13.00
Commercial valuation of one ton	13.41	11.87	12.61
Cost of one pound of phosphoric acid	2.2 cents	1.9 cents	2.1 cents

The selling price ($13) is too high for ordinary conditions in this State. It is known that it can be obtained by farmers for $8.50 a ton. At this price, one pound of insoluble phosphoric costs about 1.4 cents.

AMOUNT AND COST OF PLANT-FOOD IN CALCIUM (LIME) COMPOUNDS.

Calcium or lime compounds are being used in increasing amounts by farmers for application to soils. The forms in use are ground limestone (impure calcium carbonate), slaked or hydrated lime (calcium hydroxide), usually mixed with more or less carbonate, and quicklime, or burned lime (calcium oxide). These forms all vary much in the amount of calcium they contain. Nearly all samples contain magnesium compounds, varying in amount from 1 or 2 per ct. to nearly 40. Magnesium carbonate, hydroxide and oxide are useful in neutralizing acids in soils, their neutralizing power being greater, pound for pound, than the corresponding calcium compounds. In the table below, we give the percentages of calcium (Ca) to include magnesium (Mg) (the magnesium being previously calculated to an equivalent of calcium).

TABLE XVI.—AMOUNT AND COST OF CALCIUM IN LIME COMPOUNDS.

	Highest.	Lowest.	Average.
Materials containing *Calcium Carbonate* (ground limestone, marl, etc.)			
Pounds of calcium and magnesium in 100 pounds	40.72	34.42	38.75
Selling price of one ton....................	$6.60	$4.00	$5.56
Cost of one pound of calcium (Ca.)...........	0.95 cent	0.50 cent	0.72 cent
Materials containing *Calcium Hydroxide*, etc. (slaked or hydrated lime)			
Pounds of calcium and magnesium in 100 pounds	62.50	46.68	54.62
Selling price of one ton....................	$7.50	$5.75	$7.05
Cost of one pound of calcium (Ca.)...........	0.73 cent	0.55 cent	0.65 cent
Materials containing *Calcium Oxide* (quicklime)			
Pounds of calcium and magnesium in 100 pounds	68.09	57.19	63.84
Selling price of one ton....................	$8.50	$4.75	$6.65
Cost of one pound of calcium (Ca)...........	0.65 cent	0.40 cent	0.52 cent

In the samples examined by us the average cost of calcium is greatest in the form of carbonate, and least in that of quicklime, while in the form of slaked lime the cost is intermediate. Even the minimum prices found above are high in comparison with the prices at which these materials can be purchased. Ground limestone containing nearly 40 per ct. of calcium and magnesium can be obtained by many farmers in this State at a cost of $2.50 per ton, in which case the cost of one pound of calcium is about 0.3 cent. Quicklime can be

obtained at $4 to $5 a ton, furnishing calcium at about the same price (0.3 cent a pound).

In this connection, it is in place to mention that one sample of calcium sulphate (gypsum or land-plaster) was found containing 26.75 per ct. of calcium, and selling at $10 a ton. In this case each pound of calcium costs 1.9 cents. It may be added that calcium in this form has no value in neutralizing soil acidity.

COMPOSITION AND COST OF MIXTURES CONTAINING LIME, PHOSPHORIC ACID AND POTASH COMPOUNDS.

Quite recently mixtures have come into the market which contain calcium carbonate in the form of ground limestone or marl together with muriate or sulphate of potash and ground rock phosphate or acid phosphate. Some of the mixtures are intended by the makers to imitate wood-ashes in composition.

TABLE XVII.— AMOUNT AND COST OF CALCIUM, PHOSPHORIC ACID AND POTASH IN SPECIAL MIXTURES.

	Highest.	Lowest.	Average.
Pounds of phosphoric acid in 100 pounds	8.10	2.42	4.48
Pounds of potash in 100 pounds	5.30	4.30	4.97
Pounds of calcium in 100 pounds	44.48	27.40	32.50
Selling price of one ton	$20.00	$12.50	$17.12
Commercial valuation of one ton	10.37	6.80	9.01
Cost of one pound of phosphoric acid	12 cents	4 cents	7.6 cents
Cost of one pound of potash	12 cents	5.4 cents	7.6 cents
Cost of one pound of calcium	1.5 cents	0.7 cent	0.95 cent

From the standpoint of economy in the purchase of plant-food, these mixtures do not appear to offer any advantage. Plant-food can be purchased much more cheaply in the usual forms found in the market. The cost of phosphoric acid and potash in these mixtures averages considerably higher even than in low-grade complete fertilizers.

SUMMARY OF RESULTS RELATING TO COST OF PLANT-FOODS IN FERTILIZERS.

In Table XVIII we bring together in condensed form the results that have been presented in the preceding pages, making them more available for comparison.

TABLE XVIII.— COST OF ONE POUND OF PLANT-FOOD TO FARMERS.

	Highest.	Lowest.	Average.
	Cents.	*Cents.*	*Cents.*
Nitrogen in			
Low-grade complete fertilizers	42.5	22.0	32.5
Medium-grade complete fertilizers	45.8	19.5	28.9
Medium high-grade complete fertilizers	44.2	19.5	26.9
High-grade complete fertilizers	33.0	15.8	24.2
Average of all complete fertilizers	....	....	27.0
Bone and potash mixtures	63.2	27.1	33.5
Bone-meal, etc	36.1	17.2	24.5
Tankage (meat and bone)	26.0	13.4	22.0
Tankage (meat)	28.0	20.7	24.4
Dried blood	23.8	19.4	21.6
Sodium nitrate	21.0	16.0	17.8
Commercial dried sheep manure	107.0	43.0	69.0
Fish-scrap	24.0	21.4	22.5
Phosphoric Acid in			
Low-grade complete fertilizers	9.3	4.8	7.1
Medium-grade complete fertilizers	10.0	4.2	6.3
Medium high-grade complete fertilizers	9.6	4.2	5.9
High-grade complete fertilizers	7.2	3.4	5.3
Average of all complete fertilizers	....	....	5.9
Acid phosphate and potash mixtures	9.1	4.3	5.6
Bone and potash mixtures	11.8	5.0	6.2
Acid phosphate (dissolved rock)	8.3	3.5	4.95
Bone-meal, etc	6.7	3.2	4.6
Tankage	4.8	2.5	4.1
Commercial dried sheep manure	20.0	8.0	10.0
Wood-ashes	21.7	20.3	21.0
Fish-scrap	4.3	3.8	4.1
Basic-slag phosphate	6.1	5.0	5.6
Ground rock-phosphate (floats) — insoluble	1.9	2.2	2.1
Mixtures of compounds of calcium, phosphoric acid and potash	12.0	4.0	7.6
Potash in			
Low-grade complete fertilizers	9.8	5.1	7.5
Medium-grade complete fertilizers	10.6	4.5	6.7
Medium high-grade complete fertilizers	9.7	4.5	6.2
High-grade complete fertilizers	7.7	3.6	5.6
Average of all complete fertilizers	....	....	6.2
Acid phosphate and potash mixtures	9.6	4.6	5.9
Bone and potash mixtures	12.5	5.3	6.7
Muriate (potassium chloride)	5.6	4.0	4.7
Sulphate (potassium sulphate)	6.0	5.5	5.7
Kainit (low-grade potassium chloride)	7.0	4.4	5.4
Commercial dried sheep manure	69.0	13.0	16.0
Wood-ashes	31.0	29.0	30.0
Mixtures of compounds of calcium, phosphoric acid and potash	12.0	5.4	7.6

Table XVIII (*concluded*)

	Highest.	Lowest.	Average.
	Cents.	*Cents.*	*Cents.*
Calcium and Magnesium in			
Calcium carbonate (ground limestone, marl, etc.)	0.95	0.50	0.72
Calcium hydroxide (slaked or hydrated lime)	0.73	0.55	0.65
Calcium oxide (quicklime, burned lime, etc.)	0.65	0.40	0.52
Mixtures of compounds of calcium, phosphoric acid, etc	1.50	0.70	0.95

II. THE RELATION OF GUARANTEED TO ACTUAL COMPOSITION IN FERTILIZERS.

While Bulletin No. 390 gives data that will enable one to calculate the difference between the guaranteed and actual composition of fertilizers in individual samples, it is desirable to have a more comprehensive knowledge of present conditions than can be obtained by such a casual examination. The following tables will furnish numerous details relating to this feature in connection with complete fertilizers.

Table XIX.— Difference Between Guaranteed and Actual Percentages of Nitrogen, Phosphoric Acid and Potash in Complete Fertilizers.

Complete fertilizers.	Guaranteed.	Found.	Average per ct. found above guaranty.
Nitrogen — Highest per ct	9.88	9.81	....
Nitrogen — Lowest per ct	0.20	0.31	....
Nitrogen — Average per ct	2.08	2.16	0.08
Available phosphoric acid — Highest per ct	13.00	16.04	....
Available phosphoric acid — Lowest per ct	0.40	0.58	....
Available phosphoric acid — Average per ct	7.60	8.04	0.44
Potash — Highest per ct	12.00	13.06	....
Potash — Lowest per ct	0.10	0.12	....
Potash — Average per ct	5.70	6.04	0.34

In connection with the preceding table the following statements give additional details:

(1) *Nitrogen.* In 446 samples of complete fertilizers, the amount of nitrogen is found equal to or above the amount guaranteed, the excess varying from 0.01 to 2.29 per ct., and averaging 0.17 per ct. In 166 samples, the nitrogen is below the amount guaranteed, the deficiency varying from 0.01 to 1.09 per ct. and averaging 0.16 per ct.

(2) *Phosphoric acid.* In 500 samples the amount of available phosphoric acid is above the amount guaranteed, the excess varying 0.01 to 4.04 per ct. and averaging 0.69 per ct. In 112 samples, the available phosphoric acid is below the amount guaranteed, the deficiency varying from 0.01 to 1.74 per ct. and averaging 0.51 per ct.

(3) *Potash.* In 461 samples the amount of potash is above the amount guaranteed, the surplus varying from 0.02 to 5.47 per ct. and averaging 0.59 per ct. In 151 samples the amount of potash is below the amount guaranteed, the deficiency varying from 0.01 to 2.36 per ct. and averaging 0.36 per ct.

It is a matter of interest to go into some further detail and see the number of samples going above or below the guaranty within certain limits. This information is furnished by the following tabulated arrangement of data.

TABLE XX.— NUMBER OF SAMPLES ABOVE AND BELOW GUARANTEED AMOUNTS.

COMPLETE FERTILIZERS.	NITROGEN.		PHOSPHORIC ACID.		POTASH.	
	Above in number of samples.	Below in number of samples.	Above in number of samples.	Below in number of samples.	Above in number of samples.	Below in number of samples.
Between 0 and 0.10 per ct.	159	95	29	35	53	50
" 0.10 " 0.20 "	155	24	45	25	59	21
" 0.20 " 0.30 "	68	12	39	17	52	18
" 0.30 " 0.40 "	31	15	55	11	57	14
" 0.40 " 0.50 "	24	9	47	6	48	10
" 0.50 " 0.60 "	2	4	47	5	30	4
" 0.60 " 0.70 "	4	2	42	4	31	8
" 0.70 " 0.80 "	1	1	39	2	18	10
" 0.80 " 0.90 "	2	2	33	5	16	4
" 0.90 " 1.00 "	1	0	24	0	23	3
" 1.00 " 1.50 "	0	2	69	1	43	4
" 1.50 " 2.00 "	0	0	20	1	18	4
" 2.00 " 2.50 "	1	0	4	0	6	1
" 2.50 " 3.00 "	0	0	3	0	4	0
Above 3.00	0	0	6	0	5	0
Total	448	166	502	112	463	151

In connection with the data contained in the preceding table, attention is called to the following points:

(1) For each of the three elements the number of samples showing results above the guaranteed statement of analysis is much larger than the number below.

(2) The largest number below guaranty is in case of nitrogen (166 samples), followed by potash (151 samples), while the smallest number (112 samples) below is in case of phosphoric acid.

(3) Comparatively few samples are below guaranty more than 0.50 per ct., 11 in case of nitrogen, 18 in case of phosphoric acid and 38 in case of potash.

(4) Balancing all the cases of excess and deficiency, we find that there is an average excess of 0.08 per ct. of nitrogen, 0.44 per ct. of available phosphoric acid and 0.34 per ct. of potash; these amounts have a money value of about $1.08 for one ton of fertilizer.

In the table following we give the composition, guaranteed and actual, of the fertilizing materials and mixtures other than those already considered:

DIFFERENCE BETWEEN GUARANTEED AND ACTUAL PERCENTAGES OF NITROGEN.

TABLE XXI.— PHOSPHORIC ACID, POTASH AND CALCIUM IN FERTILIZING MATERIALS.

SPECIAL MIXTURES AND UNMIXED MATERIALS.	GUARANTEED.			FOUND.			Average amount found above guaranty
	Highest.	Lowest.	Average.	Highest.	Lowest.	Average.	
	Per ct.	*Per ct.*	**Per ct.**	*Per ct.*	*Per ct.*	**Per ct.**	**Per ct.**
Nitrogen in							
Sodium nitrate	15.23	14.80	**14.94**	15.66	14.82	**15.20**	**0.26**
Dried blood	13.16	9.84	**10.54**	13.63	9.05	**10.75**	**0.21**
Bone	4.53	1.65	**2.94**	4.21	2.02	**3.12**	**0.18**
Tankage (meat and bone)	7.41	2.67	**5.28**	7.41	2.90	**5.58**	**0.30**
Tankage (meat)	11.00	6.10	**8.39**	11.98	7.46	**9.16**	**0.77**
Ground fish	9.60	6.58	**8.70**	9.75	5.62	**8.83**	**0.13**
Bone and potash salts	2.47	2.47	**2.47**	2.88	2.56	**2.71**	**0.24**
Dried sheep manure	2.36	1.00	**1.94**	2.53	1.99	**2.23**	**0.29**
Phosphoric acid in							
Acid phosphate	16	11	**13.87**	17.21	11.65	**14.65**	**0.78**
Acid phosphate and potash salts	13	6	**10.22**	13.35	6.50	**10.60**	**0.38**
Bone	23	13.73	**21.20**	27.68	15.82	**23.33**	**2.13**
Tankage (meat and bone)	21.24	6.60	**12.81**	21.30	7.46	**14.19**	**1.38**
Bone and potash salts	15	3.50	**12.12**	17.60	4.33	**13.11**	**0.99**
Ground fish	7.00	6.00	**6.55**	7.30	5.67	**6.50**	***0.05**
Basic-slag phosphate	17.00	17.00	**17.00**	19.26	17.12	**17.88**	**0.88**
Rock-phosphate (floats)	30.00	30.00	**30.00**	33.54	29.68	**31.52**	**1.52**
Wood-ashes	1.50	0.50	**1.00**	1.70	0.98	**1.34**	**0.34**
Mixtures of compounds of calcium phosphorus, etc.	8.00	2.50	**4.33**	8.10	2.42	**4.48**	**0.15**
Dried sheep manure	2.50	0.70	**1.25**	2.61	0.66	**1.56**	**0.31**

TABLE XXI (*concluded*).

SPECIAL MIXTURES AND UNMIXED MATERIALS.	GUARANTEED.			FOUND.			Average amount found above guaranty
	Highest.	Lowest.	Average.	Highest.	Lowest.	Average.	
	Per ct.	*Per ct.*	**Per ct.**	*Per ct.*	*Per ct.*	**Per ct.**	**Per ct.**
Potash in							
Potassium chloride (muriate)	50.00	48.00	**49.15**	53.50	45.14	**49.80**	**0.65**
Potassium sulphate	48.00	47.00	**47.80**	52.70	48.64	**50.17**	**2.37**
Kainit	12.40	12.00	**12.07**	14.40	11.44	**13.00**	**0.93**
Acid phosphate and potash salts	10.00	2.00	**5.53**	10.90	2.00	**5.59**	**0.06**
Bone and potash salts	5.00	2.50	**4.38**	7.64	2.81	**5.10**	**0.72**
Dried sheep manure	1.80	1.00	**1.23**	5.40	1.21	**2.31**	**1.08**
Wood-ashes	6.00	1.00	**3.25**	5.52	3.26	**3.95**	**0.70**
Mixtures of compounds of calcium phosphoric acid, etc	5.00	3.00	**4.50**	5.30	4.30	**4.97**	**0.47**
Calcium in							
Carbonates (limestone, marl, etc.)	39.00	33.50	**35.60**	38.50	25.65	**34.04**	***1.53**
Hydroxides (slaked lime)	50.00	26.45	**39.44**	50.60	29.75	**42.54**	**2.10**
Oxides (quicklime)	64.00	43.00	**53.50**	65.55	61.75	**63.65**	**10.15**
Mixtures of compounds of calcium, potash, etc	28.60	22.90	**26.30**	29.30	20.90	**26.62**	**0.32**

* Below guarantee.

In connection with data relating to calcium compounds, it should be stated that the guaranteed and actual figures are comparable only on the basis of calcium because only calcium is considered in the guaranteed statements. Most of the materials contain magnesium also, and if this were taken into consideration with the calcium, the amounts above guaranty would be considerably greater. Carbonates would show a surplus over guaranty of 3.25 per ct. (instead of a deficiency of 0.98 per ct.); hydroxides, 14.22 per ct.; oxides, 11.90 per ct.

In general, if we consider only the average results, the showing is good, but it is desirable to pay attention also to some details in order to show more clearly some of the extreme cases of variation above and below guaranty, and this is done in the table following. We give the highest and lowest and average amounts found above and below the guaranteed amounts in the case of each constituent of special mixtures and unmixed materials.

An examination of the data in Table XXII leads to the following statements:

(1) In such materials as sodium nitrate, basic slag, rock-phosphate (floats), potassium sulphate, kainit, bone and potash mixtures, the number of samples below guaranty is within reasonable limits.

Table XXII.— Highest and Lowest Percentage Differences between Guaranteed and Actual Composition.

	Above Guaranty.			Below Guaranty.		
	Number of samples.	Highest.	Lowest.	Number of samples.	Highest.	Lowest.
		Per ct.	*Per ct.*		*Per ct.*	*Per ct.*
Sodium nitrate — nitrogen.	33	0.70	0.02	2	0.27	0.02
Dried blood — nitrogen....	12	0.59	0.03	2	0.82	0.32
Acid phosphate — phosphoric acid..............	50	4.16	0.02	7	1.35	0.01
Basic slag phosphate — phosphoric acid..........	5	2.96	0.12	0	0	0
Rock-phosphate (floats) — phosphoric acid..........	3	3.54	1.38	1	0.07	....
Potassium chloride (muriate) — potash..........	20	5.50	0.12	7	4.86	0.56
Potassium sulphate — potash...................	5	4.70	1.12	0	0	0
Kainit — potash..........	9	2.40	0.04	2	0.56	0.10
Bone — nitrogen..........	22	1.21	0.04	11	0.37	0.01
Bone — phosphoric acid...	29	9.88	0.08	4	1.32	0.30
Tankage (meat) — nitrogen	3	1.36	0.98	1	0.25	....
Tankage (meat and bone) — nitrogen............	12	1.25	0.03	4	0.39	0.01
Tankage (meat and bone) — phosphoric acid......	14	6.48	0.12	2	6.52	0.29
Bone and potash salts — nitrogen...............	4	0.41	0.09	0	0	0
Bone and potash salts — phosphoric acid.........	4	2 60	0.14	0	0	0
Bone and potash salts — potash................	3	2.64	0.31	1	0.63	....
Ground fish — nitrogen....	2	0.15	0.10	1	0.96	....
Ground fish — phosphoric acid..................	1	0.20	......	1	0.33	....
Dried sheep manure — nitrogen...............	6	1.30	0.01	2	0.06	0.01
Dried sheep manure — phosphoric acid.........	6	1.74	0.04	2	0.85	0.04
Dried sheep manure — potash................	8	4.40	0.12	0	0	0
Acid phosphate and potash salts — phosphoric acid...	97	1.74	0.02	20	0.63	0.01
Acid phosphate and potash salts — potash..........	73	1.98	0.02	44	1.57	0.02
Wood-ashes — phosphoric acid..................	2	0.48	0.20	0	0	0
Wood-ashes — potash.....	1	2.26	......	2	0.48	0.34
Mixtures of calcium, potash, etc.— phosphoric acid...	2	0.43	0.10	1	0.08	....
Mixtures of calcium, potash, etc.— potash...........	3	1.30	0.26	1	0.50	....

TABLE XXII (*concluded*).

	ABOVE GUARANTY.			BELOW GUARANTY.		
	Number of samples.	Highest.	Lowest.	Number of samples.	Highest.	Lowest.
		Per ct.	*Per ct.*		*Per ct.*	*Per ct.*
Mixtures of calcium, potash, etc.— calcium	2	3.90	0.70	2	2.90	1.20
Carbonates (limestone, etc.) — calcium	7	4.65	0.20	2	0.56	0.25
Hydroxides (slaked lime) — calcium	4	2.80	1.40	6	10.05	0.10
Oxides (quicklime) — calcium	1	22.55	......	1	2.25	....

(2) In materials such as acid phosphate, potassium chloride (muriate), bone, tankage, sheep manure, mixtures of acid phosphate and potash, wood-ashes and compounds containing calcium, a larger proportion of samples is below guaranty than is desirable from the purchaser's standpoint.

A clearer understanding of what these values mean can be gained from Table XXIII, in which we give the commercial valuation of the extreme surplus and deficiency and also of the average for each plant-food constituent on the basis of one ton.

While the general averages show, in case of almost every material, a greater value in plant-food than is guaranteed, it is obvious that, when we come to consider special cases, the loss to the purchaser is one of serious magnitude. For example, we find dried blood containing $3.69 less plant-food than guaranteed; muriate of potash, $3.90; tankage, $6.90 ($1.68 nitrogen and $5.22 phosphoric acid); ground fish, $4.13, etc.

III. SOME DEFECTS IN THE PRESENT FERTILIZER LAW.

Until 1910 the law relating to the sale of commercial fertilizers made it a violation if chemical analysis showed a deficiency below the manufacturer's guaranteed statement of composition exceeding one-third of one per ct. of nitrogen or one-half of one per ct. of phosphoric acid or of potash or, in case of bone, one per ct. of phosphoric acid. In 1910 the section of the law relating to deficiencies in constituents was changed so as to read as follows: "It shall also be a violation of the provisions of this article if any commercial fertilizer or

Table XXIII.— Highest and Lowest Monetary Differences between Guaranteed and Actual Composition.

	Value Above Guaranty.		Value Below Guaranty.		Average value per ton above guaranty.
	Highest.	Lowest.	Highest.	Lowest.	
Sodium nitrate — nitrogen	$2.31	$0.06	$0.89	$0.06	$0.86
Dried blood — nitrogen	2.66	0.14	3.69	1.44	0.95
Acid phosphate — phosphoric acid	3.54	0.02	1.15	0.01	0.66
Potassium chloride (muriate) — potash	4.40	0.10	3.90	0.45	0.52
Potassium sulphate — potash	4.70	1.12	0.00	0.00	2.37
Kainit — potash	1.92	0.03	0.45	0.08	0.75
Acid phosphate and potash salts — phosphoric acid	1.48	0.02	0.54	0.01	0.32
Acid phosphate and potash salts — potash	1.58	0.02	1.26	0.02	0.05
Tankage (meat) — nitrogen	5.85	4.21	1.08	1.08	3.31
Tankage (meat and bone) — nitrogen	5.38	0.13	1.68	0.04	1.29
Tankage (meat and bone) — phosphoric acid	5.18	0.10	5.22	0.23	1.10
Bone — nitrogen	4.20	0.17	1.59	0.04	0.77
Bone — phosphoric acid	7.80	0.06	1.06	0.24	1.70
Bone and potash salts — nitrogen	1.76	0.39	0	0	1.03
Bone and potash salts — phosphoric acid	2.08	0.11	0	0	0.79
Bone and potash salts — potash	2.11	0.24	0.50	0.50	0.58
Ground fish — nitrogen	0.65	0.43	4.13	4.13	0.56
Ground fish — phosphoric acid	0.16	0.16	0.26	0.26	*0.04
Dried sheep manure — nitrogen	5.59	0.04	0.26	0.04	0.68
Dried sheep manure — phosphoric acid	1.39	0.03	0.68	0.03	0.25
Dried sheep manure — potash	3.52	0.10	0	0	0.86
Wood-ashes — phosphoric acid	0.48	0.20	0	0	0.34
Wood-ashes — potash	2.26	2.26	0.48	0.34	0.70
Mixtures of calcium, potash, etc. — phosphoric acid	0.34	0.08	0.06	0.06	0.12
Mixtures of calcium, potash, etc. — potash	1.04	0.21	0.40	0.40	0.38
Mixtures of calcium, potash, etc. — calcium	0.39	0.07	0.29	0.12	0.03
Carbonates (limestone, etc.) —calcium	0.47	0.02	0.06	0.03	*0.15
Hydroxides (slaked lime) — calcium	0.28	0.14	1.00	0.01	0.21
Oxides (quicklime) — calcium	2.25	2.25	0.23	0.23	1.02

* Below guaranty.

material to be used as a fertilizer shall contain a smaller percentage of nitrogen, phosphoric acid, potash or calcium oxide than is certified in said statement to be contained therein, when such deficiency shall be greater than ten per centum of any one of such constituents unless there be a monetary equivalent in excesses in other guaranteed constituents as provided herein; provided such deficiency does not exceed 20 per centum of such guarantee in any one constituent point. The basis of values of such constituents necessary in making such computations shall be determined by the commissioner of agriculture."

It is a matter of interest, as well as of importance, to see how the present law works in practice in comparison with the former. We will make such a comparison based on the analyses of about 1000 samples of fertilizers, as given in Bulletin No. 390. We will consider (1st) the number of cases that would appear as violations under the former provisions of the law and the number occurring under the present law, (2nd) the amount and value of the constituents deficient in these samples, and (3rd) some suggestions for remedy of the defects that are shown in the present law.

TABLE XXIV. NUMBER OF VIOLATIONS UNDER FORMER AND PRESENT LAWS.

	Number of violations under former law.	Number of violations under present law.	Number of samples analyzed.
A. *Complete fertilizers*	68	27	614
B. *Fertilizing materials:*			
Acid phosphate	3	0	57
Acid phosphate and potash	14	3	117
Dried blood	2	0	14
Muriate of potash	8	0	27
Kainit	1	0	11
Tankage	3	1	20
Bone	5	2	34
Fish	1	1	3
Other materials and mixtures	......	......	107
Total of all	105	34	1,004

An examination of the table above shows in general that under the present law many cases are not violations which would be such under

the former law. Under the present law there is a total of 34 cases of violation, while under the former law there would be 105, or 71 more than at present. It is desirable to know why the difference is so large and also whether the new law always works in favor of proper protection of purchasers of fertilizers.

AMOUNTS OF DEFICIENCY EXEMPT.

Under the former law, specific amounts were permitted in the way of deficiency below guaranty (0.33 per ct. of nitrogen, and 0.50 per ct. each of phosphoric acid and potash); under the present law a sliding scale is permitted, resulting in an absolute exemption of deficiencies amounting in all cases to 10 per ct. of the amount guaranteed. To show more fully just what this means the following arrangement furnishes data:

Table XXV.— Showing Amounts of Deficiencies of Constituents Exempt Under Present Law.

Amount of guaranty.	Amount of deficiency exempt.	Amount of guaranty.	Amount of deficiency exempt.	Amount of guaranty.	Amount of deficiency exempt.
Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1.00	0.10	**5.00**	**0.50**	10.00	1.00
2.00	0.20	6.00	0.60	15.00	1.50
3.00	0.30	7.00	0.70	20.00	2.00
3.30	**0.33**	8.00	0.80	30.00	3.00
4.00	0.40	9.00	0.90	50.00	5.00

Applying the data in this table to our discussion, it is obvious that in the case of nitrogen, for example, the present law absolutely exempts smaller amounts than did the former law until we reach the guaranty of 3.30 per ct., at which particular figure the former and present exemptions are identical. *In all cases where the nitrogen guaranty is above 3.30 per ct., then the 10 per ct. deficiency exemption exceeds 0.33 per ct., that is, the amount of absolute exemption is more by the present than by the former law.* For example, in a fertilizer guaranteed to contain 5 per ct. of nitrogen, the present law permits an absolute exemption of a deficiency of 0.50 per ct. as against 0.33 per ct. under the

former law; and the higher the amount of nitrogen guaranteed, the greater becomes the amount of deficiency exemption under the present law. As a further illustration, take nitrate of soda, guaranteed to contain 15 per ct. of nitrogen; a deficiency of 1.50 per ct. is at present permissible, requiring that the amount of nitrogen actually contained in the nitrate shall not exceed 13.50 per ct.

In the case of phosphoric acid and potash, the present law exempts smaller amounts of deficiency than did the former law until the guaranty exceeds 5 per ct., at which particular point the figure (0.50 per ct.) is the same for both the present and former laws. *Therefore, in all cases where the guaranteed amount of phosphoric acid or potash is above 5 per ct., then the 10 per ct. deficiency exemption of the present law exceeds 0.50 per ct. and becomes greater under the present law than under the former.* For example, in a fertilizer guaranteed to contain 10 per ct. of phosphoric acid or of potash, the present law permits an absolute exemption of 1.00 per ct. deficiency as against 0.50 per ct. by the former law. The exemption becomes, of course, greater in the case of higher guarantees; thus with acid phosphate carrying a guaranty of 14 per ct. of phosphoric acid, we have an exemption of 1.40 per ct.; and with muriate of potash guaranteed to contain 50 per ct., the exemption becomes 5.00 per ct., that is, such an acid phosphate needs under the present law to contain only 12.60 per ct. of phosphoric acid, and such a muriate needs to contain only 45 per ct. of potash. Summarized in brief form, it is obvious that in comparison with the former law:

(1) *The present law works to the advantage of the farmer in those cases in which the fertilizers contain less than 3.30 per ct. of nitrogen or 5.00 per ct. of phosphoric acid or potash;*

(2) *The present law works against the protection of the farmer and in favor of the manufacturer in those cases in which the guaranteed amount of nitrogen exceeds 3.30 per ct., or in case of phosphoric acid and potash 5.00 per ct.*

It therefore becomes a matter of interest and importance to learn to what extent fertilizers contain amounts of nitrogen above and below 3.30 per ct. and phosphoric acid and potash above and below 5.00 per ct.

This is indicated in the following tabulation:

TABLE XXVI.— NUMBER OF SAMPLES ABOVE AND BELOW CERTAIN LIMITS IN GUARANTY.

	NITROGEN GUARANTY.		PHOSPHORIC ACID GUARANTY.		POTASH GUARANTY.	
	Over 3.30 per ct.	Under 3.30 per ct.	Over 5 per ct.	Under 5 per ct.	Over 5 per ct.	Under 5 per ct.
	Number samples.	*Number samples.*	*Number samples.*	*Number samples.*	*Number samples.*	*Number samples.*
Complete fertilizers.......	106	508	597	17	355	259
Phosphoric acid and potash mixtures...............	......	......	All	0	66	51
Tankage..................	19	1	All	0	......	....
Bone.....................	12	22	All	0	......	....
Fish scrap................	All	0	All	0	......	....
Nitrates..................	All	0	......	......	......	....
Potash compounds........	......	......	......	......	All	0

A summary of this table can be made in the following statements:

(1) In complete fertilizers, the present law affords more complete protection to farmers than the former law in respect to nitrogen in all but the high-grade brands, which constitute about one-sixth of the whole number of samples analyzed.

(2) In the case of phosphoric acid, only 17 samples out of 614 contained less than 5 per ct., while in case of 597 samples the former law would favor the interests of farmers.

(3) In case of potash, 355 cases would be given better protection under the former law, and 259 under the present law.

(4) In the case of all other mixtures and materials containing phosphoric acid (such as acid phosphate, mixtures of acid phosphate and potash, tankage, bone, etc.), the present law gives less protection in every case, because the guaranteed percentage of phosphoric acid is above 5 and generally very much above that figure.

(5) In most cases of tankage, the present law affords less protection in nitrogen deficiency, while, in case of bone, about two-thirds of the samples are given better protection in nitrogen.

(6) All nitrates and all potash compounds (muriate, sulphate, kainit, etc.), are afforded less protection under the present law.

AMOUNT AND VALUE OF DEFICIENT CONSTITUENTS.

The preceding discussion makes it clear that the present fertilizer law does not, on the whole, afford to purchasers a degree of protection equal to that furnished by the former law. But we should consider at this point in more detail the amount and value of the constituents that are deficient to a sufficient extent to make the cases violations of the law, comparing the former and present laws in this respect. In the following table we give under each class of fertilizers and fertilizing materials (1) the number of samples constituting violations under both the former and present laws, (2) the highest, lowest and average

TABLE XXVII.— AMOUNT AND VALUE OF DEFICIENT CONSTITUENTS IN ONE TON.

	Number of samples.	Highest.	Lowest.	Average.
Samples of complete fertilizers deficient in nitrogen	21	....	....	....
Pounds of nitrogen below guaranty	....	21.8	6.00	11.2
Monetary equivalent of deficiency	....	$5.89	$1.62	$3.02
Samples of complete fertilizers deficient in phosphoric acid	17	....	....	....
Pounds of phosphoric acid below guaranty	....	30.2	10.2	15.0
Monetary equivalent of deficiency	....	$1.78	$0.60	$0.89
Samples of complete fertilizers deficient in potash	24	....	....	....
Pounds of potash below guaranty	....	31.6	10.2	18.2
Monetary equivalent of deficiency	....	$1.96	$0.63	$1.13
Samples of complete fertilizers deficient in nitrogen and phosphoric acid	2	....	....	....
Pounds of nitrogen below guaranty	....	6.6	6.6	6.6
Pounds of phosphoric acid below guaranty	....	34.8	16.2	25.6
Monetary equivalent of nitrogen deficiency	....	$1.78	$1.78	$1.78
Monetary equivalent of phosphoric acid deficiency	....	2.05	0.96	1.51
Samples of complete fertilizers deficient in nitrogen and potash	7	....	....	....
Pounds of nitrogen below guaranty	....	13.2	3.4	7.6
Pounds of potash below guaranty	....	31.2	13.6	20.6
Monetary equivalent of nitrogen deficiency	....	$3.56	$0.92	$2.05
Monetary equivalent of potash deficiency	....	1.93	0.84	1.28

Table XXVII (*concluded*).

	Number of samples.	Highest.	Lowest.	Average.
Samples of acid phosphate deficient..	3	....	....	....
Pounds of phosphoric acid below guaranty....................	....	27.00	15.4	19.6
Monetary equivalent of phosphoric acid deficiency................	....	$1.35	$0.77	$0.98
Sample of dried blood deficient......	2	....	....	....
Pounds of nitrogen below guaranty.	....	16.4	8.6	12.4
Monetary equivalent of nitrogen deficiency......................	....	$3.54	$1.86	$2.68
Sample of dried fish deficient........	1	....	....	....
Pounds of nitrogen below guaranty.	....	....	....	19.2
Monetary equivalent of nitrogen deficiency......................	....	....	....	$4.32
Samples of muriate of potash deficient.	8	....	....	....
Pounds of potash below guaranty..	....	97.2	11.2	38.6
Monetary equivalent of potash deficiency......................	....	$4.57	$0.53	$1.81
Sample of kainit deficient..........	1	....	....	....
Pounds of potash below guaranty..	....	....	....	11.2
Monetary equivalent of potash deficiency......................	....	....	....	$0.60
Samples of tankage deficient........	3	....	....	....
Pounds of nitrogen below guaranty.	2	7.8	7.4	7.6
Pounds of phosphoric acid below guaranty....................	1	....	....	130.4
Monetary equivalent of nitrogen deficiency....................	....	$1.72	$1.62	$1.67
Monetary equivalent of phosphoric acid deficiency................	....	....	....	5.35
Samples of bone deficient...........	5	....	....	....
Pounds of nitrogen below guaranty.	1	....	....	7.4
Pounds of phosphoric acid below guaranty....................	4	204.8	21.2	98.0
Monetary equivalent of nitrogen deficiency......................	....	....	....	$1.81
Monetary equivalent of phosphoric acid deficiency................	....	$9.42	$0.98	$3.51
Samples of acid phosphate and potash mixtures deficient..............	14	....	....	....
Pounds of phosphoric acid below guaranty....................	....	12.6	12.2	12.4
Pounds of potash below guaranty..	....	31.4	11.2	18.2
Monetary equivalent of phosphoric acid deficiency................	....	$0.71	$0.68	$0.70
Monetary equivalent of potash deficiency...........	....	1.85	0.66	1.07

amount of each deficient constituent and (3) the monetary value, based on one ton, corresponding to these deficiencies, the prices of plant-food constituents being those given in Table XVIII, which represent the average cost to farmers during 1914.

An examination of the table shows in general that the range of amounts of deficiencies is very wide and extends to most of the classes of materials examined, whether complete fertilizers, special mixtures or unmixed materials. It is also shown that, in the case of complete fertilizers, the number of cases is small in which more than one constituent is low enough to constitute a violation, there being 2 cases in which nitrogen and phosphoric acid were both deficient and 7 cases in which nitrogen and potash were low. These summarized data raise questions as to some further details, especially the efficiency of the present law in protecting the interests of purchasers. For example, how large a monetary deficiency can occur under the present law and yet not be a violation, and how does this compare with the results of the former law? This question can best be answered by a study of the actual cases before us, and below we present further details arranged so as to throw light on this phase of our discussion.

TABLE XXVIII.— DEFICIENCIES EXPRESSED IN MONETARY VALUE, COMPARING FORMER AND PRESENT LAWS.

MONETARY DEFICIENCY	COMPLETE FERTILIZERS — NUMBER OF VIOLATIONS.			FERTILIZING MATERIALS — NUMBER OF VIOLATIONS.		
	Total.	Former law.	Present law.	Total.	Former law.	Present law.
Between $0.50 and $1.00	25	25	0	18	18	0
" $1.00 and $1.50	12	12	1	3	3	1
" $1.50 and $2.00	8	5	6	6	6	2
" $2.00 and $2.50	5	5	4	2	2	0
" $2.50 and $3.00	6	6	4	1	1	0
" $3.00 and $3.50	6	6	5	1	1	0
" $3.50 and $4.00	4	4	3	1	1	0
" $4.00 and $5.00	3	3	2	2	2	1
" $5.00 and $6.00	2	2	2	1	1	1
" $6.00 and $7.00	.....	.....	.....	1	1	1
" $9.00 and $10.00	.....	.....	.....	1	1	1
Total	71	68	27	37	37	7

In explanation of the data contained in the table above, we make the following statements:

(1) On the basis of the monetary value of the deficiency of plant-food constituents, there would be 25 cases of violation under the former law in which the monetary deficiency is less than $1.00, and none of these is a violation under the present law.

(2) When the monetary deficiency lies between $1.00 and $1.50, there would be 12 cases of violation under the former law and only one of these is a violation under the present law.

(3) When the monetary deficiency is greater than $1.50 and less than $2.00, there is a total of 8 violations, 5 of which would come under the former law (3 of these being violations also under the present law); the other 3 cases are violations under the present law but not under the former. Since these 3 cases are the only ones of the kind, we will stop here to notice them in more detail. These are cases in which nitrogen is below the guaranteed amount between 10 and 20 per ct. of the guaranty, there not being enough excess of potash and phosphoric acid to make up the monetary equivalent of the deficiency of nitrogen. In these cases the nitrogen was not 0.33 per ct. below guaranty and would not, therefore, be low enough to make a violation under the former law. These 3 cases are the only ones out of 71 complete fertilizers in which there is under the present law a violation that would not come also under the former law.

(4) When the monetary deficiency lies between $2.00 and $2.50, there would be 5 violations under the former law, 4 of which are violations also under the present law.

(5) Taking the cases where the monetary deficiency is greater than $2.50, there are, all told, 21 cases which would be violations under the former law, of which 16 are violations under the present law.

(6) In the case of complete fertilizers, where the monetary deficiency exceeds $1.50, the number of violations under the present law is more nearly equal to those under the former law; but, even so, too many cases escape being violations under the new law where the monetary loss to the purchaser is in excess of $2.00 a ton.

(7) In the case of fertilizing materials, there would be a total of 37 violations under the former law, of which 7 are violations under the present law. In 18 cases in which the monetary deficiency is less than $1.00, there are no violations under the present law; in 3 cases where the deficiency is between $1.00 and $1.50, there is 1 violation under

the present law; in 6 cases where the deficiency is between $1.50 and $2.00, there are 2 violations under the present law; in 10 cases where the monetary deficiency exceeds $2.00, varying from that figure to nearly $10.00, 4 cases are violations under the present law. *The present law is obviously less effective in protecting purchasers in case of fertilizing materials than in case of complete fertilizers.*

(8) In 8 cases of complete fertilizers, in which the monetary deficiency exceeds $1.75 per ton, there is no violation under the present law; the specific amounts in these 8 cases are as follows: $1.78, $1.89, $2.21, $2.54, $2.65, $3.19, $3.62 and $4.81. In 10 cases of fertilizing materials, in which the monetary deficiency exceeds $1.65 per ton, the amounts of monetary deficiency are as follows: $1.69, $1.74, $1.75, $1.81, $2.03, $2.22, $2.70, $3.20, $3.54 and $4.57; and none of these is a violation under the present law.

(9) An examination of the details in each of these cases to ascertain why these samples fall below guaranty in monetary value to the extent shown, and yet are not violations under the present fertilizer law, leads to the following statements: (a) In the 8 cases of complete fertilizers cited above, the monetary deficiency is caused in 7 cases by deficiency of nitrogen below guaranty and in 1 case of phosphoric acid. In all the nitrogen cases the guaranty is above 4 per ct., permitting an absolute deficiency of over 0.40 per ct. of nitrogen without becoming a violation. For example, in one case, in which the percentage of nitrogen guaranteed is 7.41, the deficiency is 0.67 per ct., the monetary equivalent of which is $3.62, based on the average cost of nitrogen in complete fertilizers in this State. (b) In the 10 cases of fertilizing materials, the monetary deficiency is caused by lack of nitrogen in 5 cases (2 of tankage, 2 of dried blood and one of bone); in the other 5 cases, the deficiency is due to lack of potash in muriate, in which cases the present law permits an absolute deficiency of about 5 per ct. without becoming a violation.

SUGGESTIONS FOR REMEDY OF DEFECTS OF PRESENT FERTILIZER LAW.

Reviewing the foregoing discussion, a study of the data furnished by the results of analysis of about 1000 fertilizers examined in 1914, in relation to their bearing upon the practical working of the present fertilizer law as compared with the law in force previous to 1910, leads to the following summarized statements:

(1) Under the present law, there are 27 cases in which complete fertilizers are deficient in composition to an extent sufficient to make them violations, while under the provisions of the former law there would be 68 cases of violation, or 41 more than at present; in the case of 37 samples of fertilizing materials and special mixtures, 7 are violations under the present law, while all would be violations under the former law, or 30 more than at present.

(2) The greater number of violations occurring under the provisions of the law in force previous to 1910 is due largely to the fact that the present law exempts larger deficiencies in many cases than did the former law. This is shown especially in the case of nitrogen in high-grade complete fertilizers, dried blood, bone and tankage, and also in the case of potash in the form of muriate.

(3) In all cases the present law affords less protection to purchasers than did the former law (a) when nitrogen is present in amount exceeding 3.3 per ct. (including about one-sixth of all samples of complete fertilizers), (b) when phosphoric acid is present in amounts exceeding 5 per ct. (including 597 out of 614 samples of complete fertilizers), (c) when potash is present in amounts exceeding 5 per ct. (including 355 out of 614 samples of complete fertilizers), and (d) in the case of nearly all high-grade fertilizing materials, such as potash salts, acid phosphate, sodium nitrate, ammonium sulphate, etc. The higher the percentage of a plant-food constituent in a fertilizer, the greater is the amount of absolute exemption of deficiency, and this works against the protection of purchasers.

(4) The change from the provisions of the former law to those of the present was due to certain obvious imperfections, chief of which were the following: (a) The percentage of deficiency allowed was fixed in all cases without regard to the amount of the constituent guaranteed. For example, an exemption of .33 per ct. of nitrogen was permitted whether the fertilizer might contain 0.8 per ct. or 15 per ct., which was obviously unfair to the purchaser in the case of low-grade goods. (b) No provision was made for permitting any deficiency above the amount of exemption to be offset by any surplus of other constituents in the fertilizer. Thus in case of a fertilizer containing a deficiency of more than 0.5 per ct. of phosphoric acid, no relief was furnished even though the fertilizer might contain an excess of nitrogen and potash having a value much greater than the amount of phosphoric acid deficient. The provision in the present law permitting an offset

of excess of some constituents against deficiency in another within certain limits appears on the whole, to be working well in practice, when all conditions are considered. (c) A third serious defect of the former fertilizer law consisted in the uneven allowance made for deficiency exemption in the different constituents when the relative monetary value is considered. Thus, in allowing a deficiency of 0.33 per ct. of nitrogen, a much greater monetary value was exempted than in case of 0.5 per ct. of phosphoric acid or potash. At present prices, one pound of nitrogen is worth about four times as much as a pound of phosphoric acid or potash. Therefore, in order to have the exempted deficiencies of the different constituents made uniform on the basis of monetary value, it would be necessary either to increase the amount of phosphoric acid and potash if the amount of exempt nitrogen were kept at 0.33, or else to decrease the amount of nitrogen if the amount of exempt phosphoric acid and potash were kept at 0.5. Thus, on the basis of monetary value, 0.33 per ct. of nitrogen equals about 1.30 per ct. of phosphoric acid or potash; or the amount of nitrogen equal to 0.5 per ct. of phosphoric acid or potash would be 0.125 per ct. It is thus seen that under the former law, the amount of exempt nitrogen deficiency was too high in relation to phosphoric acid or potash, or, expressed in another way, that the amount of exempt deficiency of phosphoric acid or potash was too low in relation to nitrogen.

(5) When the present fertilizer law was amended, the wisdom of some of the new provisions, from the farmers' standpoint, was questioned at the time by those longest familiar with conditions. The present law has now had an impartial trial, and the analysis of the results furnished under its working, as presented in the preceding pages, shows that actual cases of injustice to farmers purchasing fertilizers not only do occur but there is offered opportunity for much more extensive injustice with complete immunity to those who may gain advantage by such injustice. To be more specific, the present law is open to one serious practical objection: It permits, in the way of a deficiency, an absolute exemption of 10 per ct. of the amount of guaranty in any one constituent without further limitation, especially without reference to the actual amount and value of the deficiency thus exempted. As has already been pointed out, this may work serious loss and injustice to purchasers in the case of fertilizers and materials containing large amounts of any of the plant-food con-

stituents. Why should a deficiency exemption be allowed, for example, in case of nitrate of soda to the extent of 10 per ct. of the guaranty, which amounts per ton of nitrate to 30 pounds of nitrogen, having a value of $2.40 to $3 according to prices at present prevailing in this State? There is no good reason why any absolute exemption should be made to such an extent as will permit a seller to sell any fertilizer with impunity, when it contains, to the extent of several dollars, less plant-food than is called for by the guaranty and when the purchaser fails to receive by several dollars what he has paid for.

Another feature of the 10 per ct. exemption is that no distinction is made between the relative values of nitrogen, which is costly, and of phosphoric acid or potash, the cost of which is about one-fourth that of nitrogen. The same objection holds good here, only in greater degree, as in the case of the former law. At present no such distinction whatever is made by the 10 per ct. exemption, while in the former law some difference, though inadequate, was made by balancing 0.33 per ct. of nitrogen against 0.5 per ct. of phosphoric acid or potash. At present the 10 per ct. exemption permits equal deficiencies of nitrogen, phosphoric acid and potash.

These defects can be properly regulated only (1) by limiting the amount of the absolute exemption of deficiency of nitrogen, phosphoric acid and potash to less than the present 10 per ct. limit in all cases where the guaranty of these constituents exceeds certain amounts; and (2) by fixing such limitations in a manner that will approximately recognize the relative monetary value of nitrogen, phosphoric acid and potash. To effect such changes as will meet the most serious objections existing in the provisions of the present law, the following suggestions are made:

(1) *In the case of nitrogen, no absolute exemption greater than a deficiency of 0.30 per ct.* (*equal to 6 pounds per ton*) *should be permitted and* (2) *in the case of phosphoric acid and potash, no absolute exemption greater than a deficiency of 1 per ct.* (*equal to 20 pounds per ton*) *should be permitted.*

A few illustrations will make clear the effect of such a modification. In the case of all fertilizers or materials containing more than 3 per ct. of nitrogen, the 10 per ct. absolute deficiency of the present provision would not hold good; for example, in a fertilizer guaranteed to contain 3.5 per ct. of nitrogen, a 10 per ct. deficiency would be 0.35 per ct., which would be permitted with immunity under the present

law, but which would not be permitted under the suggested change. In such a case, exemption would, however, be permitted, provided the deficiency does not exceed 20 per ct. of the guaranty, if the other constituents are present in excess sufficient to equal the amount of monetary deficiency caused by shortage of nitrogen. In this particular case, a surplus of phosphoric acid or of potash, or of both combined, equal to 1.40 per ct. would be enough to make an exemption of the 0.35 per ct. deficiency of nitrogen.

Taking for further illustration an acid phosphate guaranteed to contain 14 per ct. of phosphoric acid, a 10 per ct. deficiency would be 1.40 per ct., which under the present law is unconditionally permissible but which under the suggested change would be a violation, since in this case, where there is no other constituent present to furnish any balancing surplus, only 1 per ct. (equal to 20 pounds per ton) of deficiency would be absolutely exempt. The percentage of the guaranty actually exempt would thus be about 7 (instead of 10 per ct. of the guaranty).

Take for another illustration a muriate of potash guaranteed to contain 50 per ct. of potash. At present there is an absolute exemption of 10 per ct. of the guaranty, which is 5 per ct. of potash (equal to 100 pounds per ton, and having a value of about $5.00). Under the suggested change a deficiency of over 1 per ct. of potash (equal to over 20 pounds per ton and worth more than $1.00) would be a violation. Expressed in another way, if such a material contained less than 49 per ct. of potash, the deficiency would constitute a violation. Instead of allowing as now an absolute exemption of 10 per ct., or 100 pounds of potash, the suggested change would permit an absolute exemption equal to only 2 per ct. of the guaranty (50 in this case) which is 1 per ct. of potash or 20 pounds per ton.

The suggested change would in large measure remedy the defects of the present law and work in the interests of farmers. An application of this suggestion to the cases considered above in Table XXVIII gives the following results: (1) Under complete fertilizers 8 cases, showing monetary deficiencies varying from $1.29 to $3.62 and averaging $2.25 per ton, which at present are absolute exemptions, would become violations, as they evidently should be. (2) Under fertilizing materials 9 cases, showing monetary deficiencies varying from $1.21 to $4.57 and averaging $2.80 a ton, which at present are absolute exemptions, would become violations. When the amounts of the

monetary deficiencies are considered, it is obvious that purchasers should receive more protection than the provisions of the present law afford.

The added protection for purchasers of fertilizers could be furnished by amending the present section 221, Chapter 435, by incorporating something like the following addition, indicated by italics:

"It shall also be a violation of the provisions of this article if any commercial fertilizer or material to be used as a fertilizer shall contain a smaller percentage of nitrogen, phosphoric acid, potash or calcium oxide than is certified in said statement to be contained therein, when such deficiency shall be greater than ten per centum of any one of such constituents unless there be a monetary equivalent in excesses in other guaranteed constituents as provided herein; provided such deficiency does not exceed twenty per centum of such guarantee in any one constituent;" *and provided further that when such ten percentum deficiency amounts to more than three-tenths of one pound of nitrogen or one pound of phosphoric acid or of potash in one hundred pounds of fertilizer or material to be used as a fertilizer, it shall be a violation unless there be a monetary equivalent in excesses in other guaranteed constituents as provided herein.* "The basis of values of such constituents necessary in making such computations shall be determined by the commissioner of agriculture."

SEED TESTS MADE AT THE STATION DURING 1913.*

M. T. MUNN.

SUMMARY.

Part I.— During the year, 292 official samples of seed were drawn from dealers' stocks by authorized representatives of the Commissioner of Agriculture. Analyses of these samples showed 17.5 per ct. to be violations of the seed law, i. e., they contained in excess of three per centum by count of foul or foreign seed and were not so labeled. Lawn grass and grass seed mixtures were the most frequent violations, with alsike clover, red clover and redtop grass, respectively, coming next in order. Seed dealers experience some difficulty in determining the percentage of foul and foreign seed by the "count" method for the purpose of labeling their stock.

Studies made upon official samples agree with the results of previous work, i. e., standards of "count for weight" of the different agricultural seeds cannot be established and used with any degree of accuracy since the number of seeds per unit weight of crop seed varies widely.

The present seed law affords only a partial protection to the purchaser of seeds, since it does not require a reasonable freedom from dodder or other noxious weed seeds, or from inert matter.

Part II.— From correspondents, 975 seed samples were received during the year, and a practical report covering the quality, noxious weed-seed content, adulterants and general appearance of each sample was given. These voluntary examinations revealed apparently the same seed-trade conditions as did the seed examinations of the previous year.

Since the enactment of the present seed law numerous inquiries have been received for purity tests in order that dealers may label their seeds to comply with the provisions of the law. The Station cannot undertake such commercial work; and under no circumstances will it assume the burden of the analytical seed work for the seed trade.

* Reprint of Bulletin No. 378, March; for Popular Edition see p. 915.

I. INSPECTION OF AGRICULTURAL SEEDS.

Part I of this Bulletin gives the results of the analyses of the official samples of agricultural seeds collected during the year 1913. These samples were collected under the provisions of Article 15 of the Agricultural Law and were transmitted for analysis to the Director of the New York Agricultural Experiment Station, in accordance with the provisions of Section 341 of said law.

These analyses and other additional information are published by the Director in accordance with said Section 341. Article 15 of the Agricultural Law, or what is known as the "Seed Law," will be found below, printed in full.

Following the tables are given, (1) a discussion of the method of analysis as required by the law in determining purity percentage by count, (2) a short method for the "count" determination of percentage of foul or foreign seed, with table showing number of seeds per unit weight of crop seed, (3) comments on the requirements of the Agricultural Seed law, and the labeling of seeds, and, lastly, (4) a summary of the results of the inspection.

PROVISIONS OF THE AGRICULTURAL LAW RELATIVE TO THE INSPECTION AND SALE OF AGRICULTURAL SEEDS.

ARTICLE 15 OF THE AGRICULTURAL LAW.*

Inspection and Sale of Seeds.

Section 340. Inspection and sale of seeds.
341. Samples, publication of results of examination.

§ 340. **Inspection and sale of seeds.** Within the meaning of this article, "agricultural seeds" are defined as the seeds of alfalfa, Canadian blue grass, Kentucky blue grass, alsike clover, crimson clover, red clover, white clover, vetch orchard grass, rape, redtop, and timothy which are to be used for sowing or seeding purposes. No person, firm or corporation shall sell, offer, expose or have in his possession for sale for the purposes of seeding, any seeds of grasses or clovers, of the kind known as agricultural seeds containing in excess of three per centum by count [*] of foul or foreign seeds, unless every receptacle, package, sack or bag containing such seeds is plainly marked or labeled with the per centum of such foul or foreign seeds contained therein.

*See page 714.

§ 341. **Samples, publication of results of examination.** The commissioner of agriculture or his duly authorized representatives shall take samples of seed in triplicate in the presence of at least one witness and in the presence of such witness shall seal such samples and shall at the time of taking tender, and if accepted, deliver to the person apparently in charge one of such samples; one of the other samples the commissioner of agriculture shall cause to be analyzed. The director of the New York agricultural experiment station shall analyze or cause to be analyzed such samples of seeds taken under the provisions of this article as shall be submitted to him for that purpose by the commissioner of agriculture and shall report such analysis to the commissioner of agriculture, and for this purpose the New York agricultural experiment station may employ experts and incur such expenses as may be necessary to comply with the requirements of this article. The result of the analysis of the sample or samples so procured, together with such additional information as circumstances advise, shall be published in reports or bulletins from time to time.

REPORT OF ANALYSES OF SAMPLES OF SEEDS COLLECTED BY THE COMMISSIONER OF AGRICULTURE DURING 1913.

Number.	Kind of seed, brand or trade name, name of dealer, and place of collection.	Composition.		
		Foreign seed.	Inert matter.	Pure seed.
		Per ct.	*Per ct.*	*Per ct.*
	ALFALFA:			
993	Ace Kirby & Root, Cooperstown.	.56	1.20	98.24
501	Alfalfa John L. Shultz & Co., Skaneateles.	.24	.60	99.16
556	Alfalfa James F. Burke, Glen Cove.	1.12	.94	97.94
624	Alfalfa Briscoe & Tupper, Churchville.	.20	.54	99.26
625	Alfalfa Carr-Leggett Hardware Co., Port Byron.	.32	.40	99.28
907	Alfalfa Francis X. Litz, Homer.	.04	.60	99.36
1009	Alfalfa W. H. Ferguson & Son, Elmira.	.08	.30	99.62
1055	Alfalfa G. L. Dana, Cobleskill.	.20	.40	99.40
1079	Alfalfa M. W. Harroway, Richmondville.	.04	.20	99.76

Report of Analyses of Samples of Seeds — (*continued*).

Number.	Kind of seed, brand or trade name, name of dealer, and place of collection.	Composition. Foreign seed.	Inert matter.	Pure seed.
		Per ct.	Per ct.	Per ct.
	Alfalfa (*concluded*):			
1083	Alfalfa C. A. Bunn, Richmondville.	.12	.10	99.78
657	Alfalfa L. R. Wallace, Middletown.	1.16	.60	98.24
629	Anchor Steele & Torrence, Batavia.	.28	.40	99.32
514	Brita F. H. Ebeling, Syracuse.	.64	1.44	97.92
515	Cayen F. H. Ebeling, Syracuse.	2.40	1.24	96.36
1076	Choice Brown Bros., Hyndsville.	.36	.30	99.34
645	Climax Superfine Alexander Davidson, Canandaigua.	.28	1.20	98.52
1096	Climax Chas. W. Whitbeck, Schenectady.	.32	1.08	98.60
1002	D. B. Alfalfa Edw. F. Dibble, Inc., Honeoye Falls.	.16	.70	99.14
1120	Eclipse Albert V. Brayton, Glens Falls.	.64	.60	98.76
513	Fancy L. L. Patterson Co., Syracuse.	.68	.90	98.42
621	Fancy R. A. Mather, Canandaigua.	.08	.90	99.02
641	Fancy Heman Glass Seed Co., Rochester.	.04	.30	99.66
650	Fancy Geo. C. Dorsey, Geneva.	.24	.60	99.16
917	Fancy A. L. Houghtailing & Sons, McLean.	.24	.66	99.10
919	Fancy Farmers Supply Store, Ithaca.	.08	.20	99.72
921	I. X. L. American Grown Fancy Frank D. Fish, Ithaca.	.48	1.22	98.30
1062	I. X. L. American Grown Fancy G. L. Dana, Cobleskill.	.24	.46	99.30
510	Strong's Fancy Recleaned Amasa M. Strong, Syracuse.	.08	.50	99.42
	Alsike Clover:			
802	Ace William H. Paddock, Wolcott.	2.05	2.50	95.45
957	Ace C. Van Buren Co., Amsterdam.	.56	.60	98.84
1061	Ace G. L. Dana, Cobleskill.	1.64	.90	97.46
1107	Ace J. J. Deming, Hoosick Falls.	1.92	.50	97.58

REPORT OF ANALYSES OF SAMPLES OF SEEDS — (*continued*).

Number.	Kind of seed, brand or trade name, name of dealer, and place of collection.	Composition.		
		Foreign seed.	Inert matter.	Pure seed.
		Per ct.	*Per ct.*	*Per ct.*
	ALSIKE CLOVER (*continued*):			
913	Alsike Clover The Hilton & Patrick Co., Truxton.	15.50	6.50	78.00
628	Alsike C. D. Loomis, Port Byron.	1.24	1.50	97.26
982	Alsike Clover A. D. Morgan, Ilion.	11.83	3.75	84.42
765	Alsike Clover Edwin B. Watson, Madrid.	5.04	2.25	92.71
767	Alsike Clover Arthur G. Reynolds, Bombay.	9.12	2.75	88.13
554	Alsike The Long Island Seed Co., New Hyde Park.	5.74	1.00	93.26
622	Alsike R. A. Mather, Canandaigua.	1.02	.75	99.23
757	Alsike The F. M. Johnson Co., North Bangor.	15.07	2.00	82.93
1077	A. L. S. Fancy Brown Bros., Hyndsville.	.24	.25	99.51
1082	B. Alsike C. A. Bunn, Richmondville.	.03	.20	99.77
1119	B. Alsike H. A. McRae & Co., Schuylerville.	.06	.15	99.79
1060	Choice C. M. G. L. Dana, Cobleskill.	2.97	1.50	95.53
1010	Choice W. H. Ferguson & Son, Elmira.	11.80	4.50	83.70
516	Cupla F. H. Ebeling, Syracuse.	20.31	6.10	73.59
402	Fancy Jamestown Electric Mills, Inc., Jamestown.	.12	.50	99.38
626	Fancy Carr-Leggett Hardware Co., Port Byron.	3.41	1.50	95.09
635	Fancy Burton F. French, Attica.	5.38	2.00	92.62
1081	Fancy C. A. Bunn, Richmondville.	.22	.70	99.08
1115	Fancy Cullen & Hanna, Middle Granville.	.37	.40	99.23
1114	Faultless J. P. Skiff, Buskirk.	.28	.70	99.02
652	Gem Frank Hill, Goshen.	.85	1.60	97.55
455	Kaiser Joseph A. Baumert, Antwerp.	6.97	2.00	91.03
1000	Kaiser S. J. Wright, West Winfield.	5.02	1.75	93.23
1074	Kaiser Seth Smith, Sharon Springs.	4.96	.25	94.79

Report of Analyses of Samples of Seeds — (*continued*).

Number.	Kind of seed, brand or trade name, name of dealer, and place of collection.	Composition. Foreign seed.	Inert matter.	Pure seed.
		Per ct.	*Per ct.*	*Per ct.*
	Alsike Clover (*concluded*):			
975	No. 50. John Best, Herkimer.	9.42	.70	89.88
605	Fancy. Brewster Crittenden & Co., Rochester.	1.58	.30	98.12
665	Queen. L. C. Smith & Sons, Monticello.	10.76	1.75	87.49
751	Queen. H. D. Thompson & Co., Malone.	11.28	2.75	85.97
978	Queen. A. J. Schweinsberg, Boonville.	10.35	1.50	88.15
1116	Reliable. C. A. Brownlee, Cambridge.	.65	1.50	97.85
	Crimson Clover:			
607	Crimson Clover. Brewster Crittenden & Co., Rochester.	.56	1.10	98.34
	Red Clover:			
409	Red Clover. O. W. Clark & Son., Buffalo.	1.59	.90	97.51
503	Red Clover. John L. Shultz & Co., Skaneateles.	4.49	.86	94.65
852	" Best ". Bedford Farmers Cooperative Assn., Mt. Kisco.	.18	.10	99.72
551	Red Clover. Charles W. Golder, Jamaica.	2.45	1.10	96.45
647	Red Clover. Alexander Davidson, Canandaigua.	1.59	.80	97.61
651	Red Clover. Frank Hill, Goshen.	4.35	1.80	93.85
654	Red Clover. George W. Sayre, Warwick.	.48	1.30	98.22
953	Red Clover. Arthur Hill & Co., Amsterdam.	1.62	.40	97.98
1099	Red Clover. Geo. Wood, Delmar.	2.25	1.30	96.45
1117	Red Colver. Champion Grain Co., Mechanicville.	1.89	2.40	95.71
1124	Red Clover. Edward O'Neil, Valley Falls.	1.86	1.30	96.84
966	Ace. Martin Collins, Johnstown.	.18	.30	99.52
996	Ace Mammoth. F. P. Bouton, Schenevus.	1.11	1.40	97.49
914	Aetna Mammoth. Babcock & Holmes, Cuyler.	11.21	4.50	84.29

REPORT OF ANALYSES OF SAMPLES OF SEEDS — (*continued*).

Number.	Kind of seed, brand or trade name, name of dealer, and place of collection.	Composition.		
		Foreign seed.	Inert matter.	Pure seed.
		Per ct.	*Per ct.*	*Per ct.*
	RED CLOVER (*continued*):			
702	Arbor. The John T. Darrison Co., Inc., Lockport.	1.02	.54	98.44
612	Anchor. Maurer-Haap Co., Rochester.	.30	.24	99.46
911	Atlas Mammoth. The Hilton & Patrick Co., Truxton.	6.96	2.10	90.94
1101	Atlas Medium. J. H. Ward, Stephentown.	7.35	1.10	91.55
1103	Atlas Mammoth. J. H. Ward, Stephentown.	6.60	1.30	92.10
856	Bond. E. V. Kratsch, Bedford Hills.	1.35	.64	98.01
974	Botan. John Best, Herkimer.	3.27	3.00	93.73
1011	Buckeye Medium. W. H. Ferguson & Son, Elmira.	4.30	1.80	93.90
1092	Choice Mammoth. C. W. & E. Grantier, Esperance.	2.16	.30	97.54
646	Choice Mammoth. Alexander Davidson, Canandaigua.	2.43	.90	96.67
1151	Choice Medium. The Hunt Hardware Co., Central Square.	6.03	1.50	92.47
755	Choice. George D. Northridge, Malone.	.51	.66	98.83
756	Climax. The F. M. Johnson Co., North Bangor.	2.82	1.30	95.88
701	Crown Medium. James O. Rignel, Lockport.	.54	.20	99.26
1068	Crown Mammoth. Melvin Burhans, Carlisle Center.	5.70	1.10	93.20
979	Eagle. C. H. Payne, Stittville.	1.65	.80	97.55
601	Elk. A. W. Gilman, Rochester.	.54	.10	99.36
618	Eureka. Perry C. Shafer Co., Brockport.	.63	.34	99.03
634	Fancy Medium. Burton F. French, Attica.	4.44	.90	94.66
619	Faultless Medium. R. A. Mather, Canandaigua.	1.89	.80	97.31
620	Faultless Mammoth. R. A. Mather, Canandaigua.	1.23	.90	97.87
965	Faultless. D. B. Abrams & Co., Gloversville.	1.47	.90	97.63
1091	F. White & Vrooman, Middleburg.	5.97	2.60	91.43
1086	F. F. Mammoth. C. A. Bunn, Richmondville.	2.49	1.80	95.71

Report of Analyses of Samples of Seeds — (*continued*).

Number.	Kind of seed, brand or trade name, name of dealer, and place of collection.	Composition. Foreign seed.	Inert matter.	Pure seed.
		Per ct.	Per ct.	Per ct.
	Red Clover (*continued*):			
906	Gem Mammoth. Byron L. Grant & Son, Cortland.	.39	.22	99.39
648	Gem Medium. Ewart & Lake, Pavillion.	1.05	.80	98.15
613	Globe Mammoth. Maurer-Haap Co., Rochester.	.57	.50	98.93
623	Globe Medium. E. R. Haysen Co., Seneca Falls.	.63	.08	99.29
970	I. X. L. Medium. Jacob Alten Est., St. Johnsville.	.03	.10	99.87
967	I. X. L. Mammoth. Mohawk Valley Cooperative Co., Fort Plain.	.15	.40	99.45
905	Kaiser Mammoth. Byron L. Grant & Son, Cortland.	5.79	1.70	92.51
753	Kaiser. H. D. Thompson & Co., Malone.	7.12	2.50	90.38
1075	Kaiser Mammcth. Brown Bros., Hyndsville.	.51	.90	98.59
988	Large. W. J. Bissell's Sons, Waterville.	1.05	.40	98.55
1070	Large. Winnie & Seeber, Seward.	.69	.60	98.71
1113	Large. J. P. Skeff, Buskirk.	1.38	.80	97.82
801	Lion Mammoth. William H. Paddock, Wolcott.	1.05	.40	98.55
1054	Mammoth. Jay G. Cross, Cobleskill.	1.50	1.30	97.20
1003	D. B. Mammoth. Edw. F. Dibble, Inc., Honeoye Falls.	.24	.40	99.36
1063	Mammoth. G. L. Dana, Cobleskill.	1.59	.80	97.61
1085	Mammoth. C. A. Bunn, Richmondville.	3.87	1.20	94.93
999	Mammoth. A. E. Ford & Son, Oneonta.	6.37	1.10	92.53
762	Mammoth Special. Herbert J. Sanford, Potsdam.	4.80	2.20	93.00
637	Mammoth. Bramer Morgan & Reding, Attica.	2.70	.24	97.06
909	Mammoth. Francis X. Litz, Homer.	2.10	.20	97.70
1080	Mammoth. Fox Bros., Richmondville.	1.77	.30	97.93
511	Mammoth. L. L. Patterson Co., Syracuse.	.24	.68	99.08
659	Mammoth. L. R. Wallace, Middletown.	6.00	2.70	91.30

REPORT OF ANALYSES OF SAMPLES OF SEEDS — (*continued*).

Number.	Kind of seed, brand or trade name, name of dealer, and place of collection.	Composition. Foreign seed.	Inert matter.	Pure seed.
		Per ct.	*Per ct.*	*Per ct.*
	RED CLOVER (*concluded*):			
1089	Mammoth. Becker & Company, Central Bridge.	1.23	1.30	97.47
761	Medium Special. Herbert J. Sandford, Potsdam.	8.10	2.75	89.15
506	Medium. Burt L. Giddings, Baldwinsville.	2.52	2.10	95.38
632	Medium. John H. Bradish, Batavia.	.39	.60	99.01
1090	Medium. White & Vrooman, Middleburg.	6.30	2.10	91.60
1118	Medium. H. A. McRae & Co., Schuylerville.	5.67	2.10	92.23
643	Medium. J. Milton McMahon, Fairport.	.18	.40	99.42
644	Medium Special. Peck Hardware Co., Canandaigua.	1.20	1.00	97.80
660	Medium. L. R. Wallace, Middletown.	3.03	2.10	94.87
1122	Medium Eclipse. Albert V. Brayton, Glens Falls.	1.53	2.50	95.97
959	Pan American. Wilber N. Carpenter & Co., Amsterdam.	1.62	1.25	97.13
1069	Pan American. J. V. S. Eldredge, Cobleskill.	3.06	2.30	94.64
1066	Paragon. Melvin Burhans, Carlisle Center.	2.85	.50	96.65
752	Queen Mammoth. H. D. Thompson & Co., Malone.	5.13	2.30	92.57
977	Queen Medium. A. H. Barber, Boonville.	11.04	.70	88.26
1064	Reliable. G. L. Dana, Cobleskill.	1.17	.62	98.21
406	Reliable. F. Knoche & Co., Hamburg.	.93	1.14	97.93
410	Reliable. J. H. Fairchild & Son, Portville.	6.59	1.70	91.71
1088	Reliable. Becker & Co., Central Bridge.	.09	.54	99.37
606	Star Mammoth. Brewster Crittenden & Co., Rochester.	.24	.40	99.36
604	Star Medium. Brewster, Crittenden & Co., Rochester.	.36	.10	99.54
508	Strong's Fancy. Amasa M. Strong, Syracuse.	1.32	.26	98.42
509	Strong's Fancy. Amasa M. Strong, Syracuse.	.39	.50	99.11
638	Superfine. William Hamilton & Son, Caledonia.	.69	.40	89.91

REPORT OF ANALYSES OF SAMPLES OF SEEDS — (*continued*).

Number.	Kind of seed, brand or trade name, name of dealer, and place of collection.	Composition.		
		Foreign seed.	Inert matter.	Pure seed.
		Per ct.	*Per ct.*	*Per ct.*
	SWEET CLOVER:			
1121	Sweet Clover Albert V. Brayton, Glens Falls.	6.40	1.00	92.60
	WHITE CLOVER:			
997	White Clover Morris Bros., Oneonta.	.99	1.22	97.79
989	White Clover W. E. Owen & Son, Utica.	2.94	1.75	95.31
616	White Clover Briggs Bros. & Co., Rochester.	1.02	1.00	97.98
614	White Clover Maurer-Haap Co., Rochester.	.43	.15	99.42
553	White Clover The Long Island Seed Co., New Hyde Park.	2.08	1.25	96.67
1095	Buff Chas. W. Whitbeck, Schenectady.	2.29	1.30	96.41
851	White Clover William A. McDonald, Yonkers.	5.58	2.00	92.42
	CANADIAN BLUE GRASS:			
403	Canadian Blue Grass Jamestown Electric Mills, Inc., Jamestown.	3.99	7.40	88.61
	KENTUCKY BLUE GRASS:			
1005	D. B. Edward F. Dibble, Inc., Honeoye Falls.	.44	10.40	89.16
1097	Climax Fancy Chas. W. Whitbeck, Schenectady.	.36	8.70	90.94
855	Fancy Cleaned E. V. Ktarsch, Bedford Hills.	.68	18.40	80.92
1109	Fancy J. J. Deming, Hoosick Falls.	.52	9.10	90.38
609	Fancy Crosman Bros. Co., Inc., Rochester.	1.02	13.20	85.78
608	Fancy Crosman Bros. Co., Inc., Rochester.	.12	24.90	74.98
518	Kentucky Blue Grass F. H. Ebeling, Syracuse.	.42	9.20	90.38
454	Kentucky Blue Grass A. H. Herrick & Son, Watertown.	.48	20.50	79.02
	LAWN GRASS:			
990	Conklin's Imperial C. E. Goodale, Richfield Springs.	15.42	47.50	37.08
1111	Lawn Grass J. J. Deming, Hoosick Falls.	.32	23.50	76.18
1100	Price's Fine Mixed Geo. H. Price, Albany.	.36	16.00	83.64

REPORT OF ANYLYSES OF SAMPLES OF SEEDS — (*continued*).

Number.	Kind of seed, brand or trade name, name of dealer, and place of collection.	Composition. Foreign seed.	Inert matter.	Pure seed.
		Per ct.	*Per ct.*	*Per ct.*
	LAWN GRASS (*concluded*):			
1110	Shady Nook, J. J. Deming, Hoosick Falls.	.44	16.70	82.86
803	Standard, Neisner Bros., Rochester.	14.85	35.90	49.25
	MILLET:			
636	German, Geo. C. Broadbooks, Attica.	1.10	.40	98.50
663	German, Matthews & Harrison, Kingston.	.70	.10	99.20
954	German, Arthur Hill & Co., Amsterdam.	.54	.10	97.36
963	Japanese, Kulbauns & Richter, Fonda.	.60	.50	98.90
661	Yellow, L. R. Wallace, Middletown.	.25	.20	99.55
	ORCHARD GRASS:			
517	Choice, F. H. Ebeling, Syracuse.	2.78	8.35	88.87
	RAPE:			
610	Dwarf Essex, Crosman Bros. Co., Inc., Rochester.	.04	3.65	96.31
1098	Dwarf Essex, Chas. W. Whitbeck, Schenectady.	.12	2.50	97.38
1006	Rape, Edw. F. Dibble, Inc., Honeoye Falls.	.08	3.87	96.05
	RED TOP:			
555	Red Top, The Long Island Seed Co., New Hyde Park.	1.42	13.00	85.58
764	Red Top, The H. A. Allen Feed Co., Massena.	.69	5.50	93.81
1073	Red Top, Eugene Lynk, Sharon Springs.	1.05	6.40	92.55
1084	Red Top, C. A. Bunn, Richmondville.	1.10	7.50	91.40
766	Ace, Edwin B. Watson, Madrid.	.74	10.30	88.96
958	Ace, C. Van Buren Co., Amsterdam.	3.57	6.50	89.93
992	Ace, Kirby & Root, Cooperstown.	1.52	8.20	90.28
504	Choice, French Mead & Co., Oxford.	2.10	9.00	88.90
995	Choice, A. E. Pratt Co., Worcester.	7.51	5.10	87.39

REPORT OF ANALYSES OF SAMPLES OF SEEDS — (*continued*).

Number.	Kind of seed, brand or trade name, name of dealer, and place of collection.	Composition. Foreign seed.	Inert matter.	Pure seed.
		Per ct.	*Per ct.*	*Per ct.*
	RED TOP (*concluded*):			
981	CX. A. D. Morgan, Ilion.	13.08	11.70	75.22
1004	D. B. Edw. F. Dibble, Inc., Honeoye Falls.	1.38	9.20	89.42
412	Eclipse. L. Y. Miller & Son, Olean.	2.95	6.90	90.15
986	Eclipse. Geo. Oster & Son, Rome.	1.25	6.30	92.45
1056	Fancy. G. L. Dana, Cobleskill.	.90	6.00	93.10
640	Fancy. James Vick's Sons, Rochester.	5.04	6.10	88.86
1112	Fancy. J. P. Skiff, Buskirk.	.05	2.20	97.75
1106	Fancy. J. J. Deming, Hoosick Falls.	.81	5.90	93.29
512	Fancy. L. L. Patterson Co., Syracuse.	.38	7.10	92.52
920	Globe. Farmers Supply Store, Ithaca.	.91	2.90	96.19
1093	Interstate. Chas. W. Whitbeck, Schenectady.	.69	5.40	93.91
658	Saber. L. R. Wallace, Middletown.	6.61	12.50	80.89
760	Valley. Boomhower Grocery Co., Plattsburg.	2.80	14.00	83.20
656	Red Top Tenna. Snyder-Fancher Co., Middletown.	21.01	14.30	64.69
	TIMOTHY:			
502	Timothy. John L. Shultz & Co., Skaneateles.	1.19	1.00	97.81
507	Timothy. Burt L. Gidding, Baldwinsville.	.43	1.00	98.57
908	Timothy. Francis X. Litz, Homer.	.32	.50	99.18
910	Timothy. Fred E. Williams, Homer.	.25	.15	99.60
552	Timothy. Chas. W. Golder, Jamaica.	.18	2.00	97.82
603	Timothy. Brewster Crittenden & Co., Rochester.	.09	.10	99.81
633	Timothy. Burton F. French, Attica.	.13	1.90	97.97
639	Timothy. William Hamilton & Son, Caledonia.	1.85	.50	97.65
653	Timothy. Ogden & Co., Warwick.	.72	.40	98.88

REPORT OF ANALYSES OF SAMPLES OF SEEDS — (*continued*).

Number.	Kind of seed, brand or trade name, name of dealer, and place of collection.	Composition. Foreign seed.	Inert matter.	Pure seed.
		Per ct.	*Per ct.*	*Per ct.*
	TIMOTHY* (*continued*):			
758	Timothy The F. M. Johnson Co., North Bangor.	.45	.40	99.15
984	Timothy Fayette Getman & Sons, Ilion.	.95	.90	98.15
994	Timothy S. S. Harrison, Milford.	.99	1.22	97.79
1012	Timothy Frank W. March, Morganville.	.59	.70	98.71
915	Acme Babcock & Holmes, Cuyler.	.05	.15	99.80
961	Acme Kulbauns & Richter, Fonda.	.11	.20	99.69
1058	Acme G. L. Dana, Cobleskill.	.18	.17	99.65
976	Amber D. B. Boynton, Newport.	.09	.60	99.31
1008	Archer W. H. Ferguson & Son, Elmira.	2.97	1.60	95.43
1104	Arrow J. H. Ward, Stephentown.	.45	1.20	98.35
853	Best Timothy Bedford Farms Cooperative Assn., Mt. Kisco.	.18	.20	99.62
1059	B. Timothy G. L. Dana, Cobleskill.	.58	1.22	98.20
1071	Bingo Winnie & Seeber, Seward.	.02	.10	99.88
962	Bingo Kulbauns & Richter, Fonda.	.02	.10	99.88
1052	Bison Jay G. Cross, Cobleskill.	1.12	1.25	97.63
980	Bison Chas. J. Clark, Holland Patent.	.85	.60	98.55
1123	Bison John J. Tracy, Ballston Spa.	.99	.70	98.31
630	Blue Jay Steele & Torrence, Batavia.	.18	.40	99.42
602	Bon A. W. Gilman, Rochester.	.22	.27	99.51
912	Cayuga The Hilton & Patrick Co., Truxton.	.09	.10	99.81
991	C & M Pure C. E. Goodale, Richfield Springs.	.02	.10	99.88
904	C & S Byron L. Grant & Son, Cortland.	.04	.10	99.86
763	Choice Herbert J. Sanford, Potsdam.	.74	.80	98.46

Report of Analyses of Samples of Seeds — (*continued*).

Number.	Kind of seed, brand or trade name, name of dealer, and place of collection.	Composition.		
		Foreign seed.	Inert matter.	Pure seed.
		Per ct.	*Per ct.*	*Per ct.*
	Timothy (*continued*):			
987	Choice C. H. Phister, Vernon.	.74	.65	98.61
615	Climax Briggs Bros. & Co., Rochester.	.58	.70	98.72
956	Colonial C. Van Buren Co., Amsterdam.	.81	.75	98.44
662	Colonial Matthews & Harrison, Kingston.	.29	.70	99.01
902	Colonial Byron L. Grant & Son, Cortland.	.19	.50	99.31
1053	Colonial Jay G. Cross, Cobleskill.	1.42	1.30	97.28
1001	D. B. Timothy Edw. F. Dibble, Inc., Honeoye Falls.	.04	.50	99.46
1105	Don J. H. Ward, Stephentown.	.38	1.70	97.92
405	Fancy Harvey Seed Co., Buffalo.	.18	.25	99.57
922	F. R. D Edward Rhoader, Waverly.	.02	.10	99.88
998	Globe Morris Bros., Oneonta.	.18	.20	99.62
611	Globe Maurer-Haap Co., Rochester.	.13	.50	99.37
1108	Globe J. J. Deming, Hoosick Falls.	.19	.75	99.06
903	Gold Byron L. Grant & Son, Cortland.	.11	.20	99.69
505	Gold Frank Mead & Co., Oxford.	.05	.15	99.80
452	Gold Medal Hermon C. Clark, Mannsville.	.11	.20	99.69
627	Gold Medal Carr-Leggett Hardware Co., Port Byron.	.27	.20	99.53
451	Honor Nelliss & Louphen, Copenhagen.	.04	.25	99.71
404	Honor Joseph Thiel, North Collins.	.05	.20	99.75
973	Honor John Best, Herkimer.	.05	.20	99.75
1094	Interstate Chas. W. Whitbeck, Schenectady.	.99	.20	98.81
411	Interstate L. Y. Miller & Sons, Olean.	.18	.15	99.67
407	Jap F. Knoche & Co., Hamburg.	.11	.25	99.64
642	Jap Burr & Starkweather Co., Rochester.	.34	.25	99.41

REPORT OF ANALYSES OF SAMPLES OF SEEDS — (*continued*).

Number.	Kind of seed, brand or trade name, name of dealer, and place of collection.	Composition. Foreign seed.	Inert matter.	Pure seed.
		Per ct.	*Per ct.*	*Per ct.*
	TIMOTHY (*continued*):			
969	Justice Chris. Fox, St. Johnsville.	.14	.30	99.56
1057	Justice G. L. Dana, Cobleskill.	.18	.25	99.57
951	King Arthur Hill & Co., Amsterdam.	.11	.10	99.79
1067	King Melvin Burhans, Carlisle Center.	.23	.50	99.27
972	Liberty G. M. Helmer, Herkimer.	.27	.25	99.48
649	Liberty Farmers Supply House, Warsaw.	.07	.25	99.68
408	Liberty F. Knoche & Co., Hamburg.	.02	.20	99.78
1065	Liberty G. L. Dana, Cobleskill.	.14	.20	99.66
664	Model L. C. Hatch & Sons, Monticello.	.67	.80	98.53
655	Navio Snyder-Fancher Co., Middletown.	.29	1.20	98.51
453	Onondaga Parker Bros., Cape Vincent.	.02	.50	99.48
916	Overrun Wm. S. Dickinson, Messengerville.	.02	.20	99.78
631	Pan American Donald G. Fraser, Batavia.	.19	.60	99.21
960	Pan American Wilber N. Carpenter & Co., Amsterdam.	.19	.15	99.66
401	Perfection Jamestown Electric Mills, Inc., Jamestown.	.07	.25	99.68
617	Pine Tree Maurice E. Phillips, Pittsford.	.16	.80	99.04
955	Pine Tree C. Van Buren Co., Amsterdam.	.11	.40	99.49
964	Pine Tree Abram Van Wagner, Gloversville.	.19	.20	99.61
1051	Pine Tree J. A. Reynolds, Albany.	.02	.10	99.88
952	Recleaned Arthur Hill & Co., Amsterdam.	.19	.05	99.76
1072	Rex Winnie & Seeber, Seward.	.70	1.00	98.30
1078	S. Timothy Brown Bros., Hyndsville.	.21	.20	99.59
759	Square Deal Boomhower Grocery Co., Plattsburg.	.22	1.25	98.53
985	Square Deal Mohawk Feed Mill, Mohawk.	.41	.75	98.84

Report of Analyses of Samples of Seeds — (*concluded*).

Number.	Kind of seed, brand or trade name, name of dealer, and place of collection.	Composition. Foreign seed.	Inert matter.	Pure seed.
		Per ct.	Per ct.	Per ct.
	Timothy (*concluded*):			
971	Star W. B. Newell. Little Falls.	.02	.15	99.83
968	State Mohawk Valley Cooperative Co., Fort Plain.	.02	.25	99.73
754	Strictly Prime George D. Northridge, Malone.	1.17	.60	98.23
983	Strictly Prime Fayette Getman & Son, Ilion.	3.29	1.70	95.01
1087	Strong C. A. Bunn, Richmondville.	.19	.70	99.11
923	Wren C. A. Dewel, Flemingville.	.23	.60	99.17
	Alsike and Timothy:			
901	Alsike and Timothy Forrest Seed Co., Cortland.	.45	.80	98.75
	Timothy and Alsike:			
918	Timothy and Alsike Robert Schutt, Dryden.	5.98	5.20	88.82
	Vetch:			
1007	Vetch Edw. F. Dibble, Inc., Honeoye Falls.	2.25	1.50	96.25

METHOD OF ANALYSIS.

Numerous inquiries have been received relative to the methods employed in making a purity test by "count" in compliance with the provisions of the seed law which requires that the percentage of foul and foreign seed shall be determined by a "count" of the number of such seeds in any given quantity of the designated crop seeds. In making the analyses reported in this Bulletin, the rules and regulations for seed testing as adopted by seed analysts were followed as closely as possible. The regulation weight of sample was used and the seed impurities counted, as were also the crop seeds in the sample. From these data the percentage of foul and foreign seed was determined by the proportional number of seeds in the sample. Inert matter, which consists of broken seed, chaff, stems, dirt, etc., was weighed and recorded as percentage by weight of the entire

sample. The sum of percentages of foul or foreign seed and of inert matter was subtracted from one hundred and the result recorded as the percentage of pure seed.

In some cases the percentage of pure seed as determined by the above method was somewhat lower than it would have been had the percentage composition been found by weight. From studies made upon the relationship between "weight" and "count" methods for determination of percentage of purity of seed it was found that in every case where the seed was well cleaned with modern cleaning machinery and the seed impurities were of about the same size and weight as the crop seed, even if they represented several species, the two methods agree closely. It was also found that the lower the grade of seed and the less the amount of cleaning it had received the smaller in size were some of the seed impurities and consequently the higher was the percentage of impurity by count as compared with the percentage of impurity by weight. The reverse would be true if the crop seed was contaminated with a foreign seed of much larger size and weight, as would be the case if timothy seed was present in a sample of redtop seed.

The analyses of several conspicuous samples may serve to illustrate the foregoing statements: A sample of redtop seed contained 515 seeds of a species of rush (*Juncus tenuis*) which represented 4.53 per ct. by count of the total number of seeds in the sample, but when weighed upon a delicate balance and the percentage recorded by weight, these 515 seeds of rush, which are very small, showed a percentage of only 0.5, a difference of over 4.0 per ct. The seeds of this rush are, in many cases, stuck together in little bunches by a mucilaginous substance, thereby making it very difficult to separate them for the purpose of counting. In this case the mucilaginous substance was dissolved with alcohol and xylol and the rush seeds counted with the aid of a binocular microscope.

A sample of alfalfa seed (No. 23), in which the seed impurities consisted mainly of timothy, gave a percentage of 2.0 by weight, or a percentage of 8.8 by count. This sample proved to be a violation of the seed law when the purity percentage was determined by the "count" method.

A sample of alsike clover seed (No. 15), which was badly contaminated with timothy and weed seeds smaller in size than those of the alsike clover, showed 9.5 per ct. foul or foreign seed by weight or 17.5 per ct. by count.

A sample of redtop seed (No. 976F), contaminated with timothy seed, because of the larger size and weight of the timothy, showed 8.0 per ct. foreign seed by weight but only 4.56 per ct. by count.

Red clover seed sample No. 22, which was badly infested with many small weed seeds, notably those of Rugel's plantain, lamb's quarters, mayweed and small-seeded dodder, showed 4.0 per ct. of such seeds by weight or 8.75 per ct. by count.

Timothy seed sample No. 1039 contained rough cinquefoil, blue grass, and sheep sorrel seeds to the extent of 4.7 per ct. by weight, or 12.6 per ct. by count. Another sample of timothy seed contained redtop grass seed, rough cinquefoil and other small weed seeds to the extent of 7.5 per ct. by weight or 17.1 per ct. by count. Timothy seed sample No. 1040F contained mouse-ear chick weed, blue grass and other small seeds to the extent of 1.0 per ct. by weight, but when the "count" method was applied the percentage of such seeds was found to be 5.9, which would constitute a violation of the seed law.

It seems evident, then, that the smaller and lighter the seed impurities are with respect to the size and weight of the crop seed in which they are found, the greater the variation in the two methods, the percentage of impurity by count increasing more rapidly than the percentage by weight as the relative size of the impurities decreases.

The foregoing facts may account for some of the apparent discrepancies in percentages of impurity of some samples collected in this State, since some dealers have based their guarantees of purity upon percentages as determined by weight and not by count as is required by the provisions of the seed law.

There are certain instances in which it appears as if it would be a practical impossibility for seedsmen to determine the exact purity percentage by count of some kinds of seed; as is illustrated in the above cited case of the redtop grass seed sample containing seeds of a species of rush. In this sample it was necessary to dissolve the mucilaginous substance surrounding the bunches of seeds with an alcoholic preparation and later count them under a low-power binocular microscope.

SHORT METHOD FOR THE COUNT DETERMINATION OF PERCENTAGE OF FOREIGN SEED.

Following the enactment, July 1, 1912, of the present seed law the writer made a study of the "count" method of purity determination

in an attempt to derive some "standards" which would represent the number of crop seeds in a given unit weight and thereby materially shorten the method of making such tests. The results of this study are reported in Bulletin No. 362 of this Station. During the past year similar studies have been made with the official seed samples, and in the main the findings agree with those obtained in 1912, namely: the number of seeds per unit weight in any one kind of seed was found to vary widely, depending upon the size of seed, locality where grown, character of season in which the seed was harvested* and (in the case of grass seeds) the grade of seed, and the extent to which the hulls or chaff had been removed from the grains; therefore, standards could not be applied with any degree of accuracy to all samples collected during any one season, and in the case of any sample the question might be raised as to the facts in regard to that particular sample if the percentage of purity was determined on the basis of an average number of seeds per unit weight for that kind of crop seed.

The demand for a short, practical method for finding the approximate percentage of foul and foreign seed in a sample seems to warrant the publication of the standards derived from counts upon official samples analyzed during the past two seasons.

Table II gives the average number of seeds per unit weight for the common crop seeds designated in the law as agricultural seeds. These averages were obtained by counts made upon unit weights of pure seed from samples obtained upon the open market by the seed inspectors during the years 1912–1913.

The operation of finding the approximate percentage of foreign seed by count may be greatly shortened by considering the seeds in a regulation weight test sample† as fractional parts, thereby giving each kind of crop seed a definite value or "factor." The "factor" designates the percentage which one seed would represent in the

* As an illustration of the extent to which the number of crop seeds per unit weight may vary from year to year, it was found by actual counts made upon redtop seed samples collected in 1912 from seed grown in 1911 that the average number of seeds per gram was 10,020, while in the case of the 1913 samples from seed grown in 1912 the average number of seeds per gram was 11,447, a difference of 1,427 seeds per gram. In the case of Kentucky blue grass samples the average number of seeds per gram for the corresponding years was 580 higher in the 1913 samples.

† For the designated agricultural seeds the regulation weight test sample would be for Canada and Kentucky blue grasses, and redtop grass seed 1 gram; alsike clover, white clover, and timothy seed, 2 grams; alfalfa, red clover, and crimson clover seed, 5 grams; rape, 10 grams; and the vetches, 30 grams.

Table II.— Average Number of Seeds per Unit Weight.

Kind of crop seed.	Number of seeds per gram.	Number of seeds in regulation sample.	Number of seeds per pound.	Factor.[3]
	Av.	*Av.*	*Av.*	
Alfalfa	506	2,529	229,431	0.040
Alsike clover	1,525	3,051	691,967	0.032
Canada blue grass	5,965	5,965	2,705,724	0.017
Crimson clover	323	1,616	146,603	0.061
Kentucky blue grass	5,297	5,297	2,402,720	0.019
Orchard grass	1,420	2,840	644,112	0.035
Rape, Dwarf Essex	230	2,303	104,464	0.043
Red clover	655	3,277	297,244	0.030
Redtop	10,733	10,733	4,868,488	0.010
Timothy	2,794	5,588	1,267,358	0.018
[1] Vetch, spring	21	638	9,616	0.156
[2] Vetch, winter	37	1,112	16,783	0.090
White clover	1,579	3,159	716,461	0.031

[1] Spring, or common vetch, *Vicia sativa.*
[2] Winter, sand, or hairy, vetch, *Vicia villosa.*
[3] See last paragraph on page 131 for explanation of the " Factor."

regulation weight of sample taken for that particular kind of crop seed, and is derived from the preceding table. After having weighed out the test sample it is spread out upon a smooth, white surface and the foul or foreign seeds counted. The number of such foul or foreign seeds found in the sample is then multiplied by the " factor " for the kind of crop seed in which the seed impurities were found, the result being the approximate percentage of such foul or foreign seed in the sample. The application of this method is based upon the assumption that every foreign seed present in the test sample usurps the place of a crop seed, and it should be understood that the method is intended to be applied only when dealing with the above designated agricultural seeds which have been recleaned and are at least of average grade. With such seeds there is no great sacrifice of accuracy with the method. This method is of greatest value when the analyst has made a mechanical separation of the seed sample for the purpose of determining percentage of purity by weight, since the foul or foreign seeds in the test sample are then easily counted and the number multiplied by the "factor" for the kind of crop seed in which they were found. The "factors" cannot be used with crop seed mixtures.

Another method for finding the approximate percentage of foul or foreign seed is to secure a well mixed representative sample, then count out 1000 seeds indiscriminately. This number of seeds is then carefully separated into pure crop seed and foul or foreign seed and the number of each determined by actual count. From these data the percentage of foul or foreign seed and of crop seed can be determined by the proportional number of seeds of each.

REQUIREMENTS OF THE AGRICULTURAL SEED LAW.

The provisions of the agricultural seed law relative to the tag or label requirements do not appear to be clear to many, or else are misinterpreted, since many inquiries are received regarding them. The law does not specify that agricultural seeds shall be 97 per ct. pure seed, allowing 3 per ct. by count of foul or foreign seed, before they may be sold without being labeled as many have been led to believe; in fact, it is simply required that every receptacle, package, sack or bag containing any of the designated agricultural seeds containing in excess of 3 per ct. by count of foul or foreign seeds shall be plainly marked or labeled with the percentage of such foul or foreign seed contained therein. In other words, a sample of seed may contain a very low percentage of pure seed, the remaining percentage being inert matter, and still not require labeling to comply with the requirements of the present seed law as long as the percentage of foul or foreign seed does not exceed 3 per ct. by count. No restriction is placed upon the amount of inert matter these agricultural seeds may contain.

It is held that mixtures of seeds containing any of the seeds named in the statute as agricultural seeds as one of the principal component parts come within the provisions of the statute, but the names of the seeds composing the mixture need not appear on the package. The package must be branded with the percentage of foul or foreign seeds when the amount of such seeds exceeds 3 per ct. by count.

LABELING.

The big problem which confronts seed dealers and farmers who have seeds for sale is that of determining the percentage of foul and foreign seed by count. Many communications, accompanied by seed samples, have been received from seedsmen, seed dealers and farmers requesting that analyses be made and the percentage compo-

sition reported in order that the sender might use the data in labeling his seeds. The answer given to such requests is that the Station does no commercial work of this nature and under no conditions whatever can it assume the burden of the analytical seed work for the trade.

Owing to the fact that the percentage composition of seed samples as secured from different seed-testing laboratories may vary to some extent it has been held that a certain range of variation be allowed since it would seem unjust to hold the dealer in seeds to a rigid standard of purity by "count." A variation in the seed itself, methods of sampling and other factors will bring about a difference in purity percentage even when similar methods of analyses are employed by different analysts upon the same sample. Where careful methods of analysis are employed it would seem that the variation in tests should not greatly exceed 1 per ct. Therefore, as a limit of tolerance, a variation of at least one-half of 1 per ct. should be allowed in either direction from the 3 per ct. by count of foul or foreign seed as specified in the seed law. In view of this fact it should be expected that lots of seed requiring it will be labeled with the approximate percentage of such foul and foreign seed contained therein. No special style of tag or label is required except that it must show plainly the percentage of foul or foreign seed in each seed container.

RESULTS OF THE INSPECTION.

During the past year 292 official samples of seed were collected and analyzed. Of these, 51, or 17.5 per ct., were violations of the seed law, that is, they contained over 3 per ct. of foul or foreign seeds by count and were not so labeled. Lawn grass and grass seed mixtures were the most frequent violations. This fact, supplemented by the results of previous examinations of similar mixtures, should serve to warn purchasers against these mixtures. Where mixtures are required it is more satisfactory to purchase pure seed of the kinds desired and mix them upon one's own premises, unless a mixture is put up by a reputable seedsman or seed dealer and can be implicitly relied upon.

The fact that 20.8 per ct. of the samples collected during 1912 were violations of the seed law as against 17.5 per ct. of violations in 1913 seems to indicate that there was a smaller amount of misnamed

seed or unlabeled seed of poor quality upon the market during the past season.

The present seed law affords only partial protection since it does not require a reasonable freedom from dodder or other noxious weed seeds, or a certain freedom from inert matter. It is therefore evident that every purchaser of seeds must, in the absence of any statement concerning the amount or nature of the impurities present, rely upon his own ability to judge of the quality of the seed he intends to purchase, since the 3 per ct. by count allowed by the law affords ample opportunity for the introduction of a large number of noxious weeds upon the farm. Upon the other hand, the fact that a quantity of seed contains in excess of 3 per ct. by count of seed impurities and is therefore labeled does not by any means indicate that such seed contains noxious weed seeds and is to be looked upon with suspicion, or is of materially lower value for seeding purposes, since some crop seeds are contaminated through natural infestation with another crop seed of similar size and weight which makes its removal a practical impossibility. A large amount of the alsike clover seed produced during the past season is contaminated with the seed of white clover to such an extent that labeling will be required in most cases. Timothy seed also occurs in alsike clover seed, in considerable amounts in many instances, through natural infestation.

Purchasers of seeds may utilize the official reports to a certain extent as a guide to the character of the seed sold by some dealers, and the uniform grade or quality of some brands of seed.

II. VOLUNTARY EXAMINATIONS FOR CORRESPONDENTS.

During the past year 975 samples of seed have been received from correspondents for purity examination. The greater proportion of the samples were those of alfalfa, with timothy and red clover coming next in number. These voluntary examinations revealed approximately the same conditions regarding the purity of the seed upon the market as was reported in Bulletin No. 362 from this Station covering the seed examinations made during the year 1912. As has been the experience of former years, a great many of the samples were entirely too small for a dependable analysis, and many

of the samples did not represent fairly the bulk from which they were drawn.

Some farmers are making a practice of securing a number of small packets or samples of seed from several seedsmen and seed dealers and then mailing them to the Station for a purity test, and later buying their seed or deciding not to buy, upon the results of these tests. Such a procedure should be discouraged, since it is decidedly unfair to honest seedsmen who place in their packets a representative composite sample of the seed they will sell under certain quotations, while other seed dealers are content to fill their sample packets with specially cleaned seed for advertising purposes. Many of these small sample packets contain varying amounts of seed from a few seeds to several grams, and in some cases as much as two ounces. It seems obvious that a comparison of reports upon such widely dissimilar and in some cases unrepresentative seed samples would be of no value as a guide in the intelligent purchase of seeds. Seed should not be bought by sample except in cases where the sample is drawn from the well mixed bulk of seed and is representative of the lot from which it is taken. Samples should contain at least two ounces of seed in most cases and should be accompanied by a time limit within which the dealer agrees to furnish the same seed in bulk.

The bearing of the seed law is being felt by farmers and seed growers who have seed for sale as is evidenced by the fact that a considerable number of samples have been received from farmers and growers who request that the percentage of pure seed be reported in order that their seed may be properly labeled before selling. The answer to these requests is that the Station cannot undertake commercial work of this nature or make seed tests for each farmer in the State, since what is granted in one case cannot rightfully be refused in another.

If the number of seed samples from farmers continues to increase as rapidly as in the past it will soon become necessary to place some limitations upon the amount of such work the Station will undertake to do.

The reports made on samples sent in for testing are for private use only and are not to be used for advertising purposes since they are not a guarantee of the lot from which the sample was taken, and are presumably accurate only for the sample submitted for examination. The Station will refuse to make tests for anyone knowingly or persistently violating this regulation.

CHANGE IN LAW.

After this Bulletin was in type, information reached the Station of an important change in the "Seed Law."

Assembly Bill No. 628 constituting Chapter 59 of the Laws of 1914, became a law with the Governor's signature on March 20, 1914. This bill amends Section 340 of the Agricultural Law in relation to seeds, and changes the method of determining the per centum of foul or foreign seed from "count" to "weight." The only change in the law as it appears on page 114 of this Bulletin is the substitution of the word "weight" for "count" in line 9 of Section 340. This makes that portion of the law now read "agricultural seeds containing in excess of three per centum by weight of foul or foreign seeds, etc."

ANALYSES OF MATERIALS SOLD AS INSECTICIDES AND FUNGICIDES.

PARIS GREEN.†

Sample number.	Certificate number.	Name and address of manufacturer and trade name or brand.	Where taken.		Arsenious oxide.	Copper oxide.	Water-soluble arsenious oxide.
					Per ct.	*Per ct.*	*Per ct.*
1250	873	A. B. Ansbacher & Co., New York City,	Albany	*G	55	——	†3.50
		Paris Green, Pure		*F	56.55	30.12	3.21
1873	873	A. B. Ansbacher & Co., New York City,	New York City	G	55	——	3.50
		Paris Green, Pure		F	56.76	29.99	3.21
1202	198	Jas. A. Blanchard, New York City,	Tarrytown	G	——	——	——
		Paris Green		F	56.65	29.06	8.39
1235	394	E. J. Barry, New York City,	Albany	G	50	——	3.50
				F	56.77	30.34	4.01
1655	382	Carpenter-Udell Chemical Co., Gd. Rapids, Mich.	Geneva	G	50	——	3.50
		Paris Green		F	58.12	30.49	3.09
1839	——	O. W. Clark & Son, Buffalo,	Buffalo	G	50	30	2
		Paris Green		F	56.39	30.32	4.56
1828	——	Detroit White Lead Works, Detroit, Mich.,	Buffalo	G	50	——	3.50
		Rogers Paris Green		F	57.11	29.69	4.26
1829	——	Detroit White Lead Works, Detroit, Mich.,	Buffalo	G	50	——	3.50
		Rogers Paris Green		F	57	30.13	3.95

*G and F stand respectively for Guaranteed and Found.

† Reprint of Bulletin No. 384, April.

ANALYSES OF MATERIALS SOLD AS INSECTICIDES AND FUNGICIDES — (*Continued*).

PARIS GREEN — (*Continued*).

Sample number.	Certificate number.	Name and address of manufacturer and trade name or brand.	Where taken.		Arseni-ous oxide.	Copper oxide.	Water-soluble arseni-ous oxide.
					Per ct.	*Per ct.*	*Per ct.*
1209	1 and 2	Devoe & Reynolds, New York City,	Tarrytown,	*G	56	———	2
		Paris Green		*F	56.82	29.96	4.93
1660	1 and 2	Devoe & Reynolds, New York City,	Seneca Castle	G	56	———	2
		Paris Green		F	56.88	30.18	4.74
1826	1 and 2	Devoe & Reynolds, New York City,	Buffalo	G	56	———	2
		Paris Green		F	56.91	30.23	4.67
1656	382	Fred L. Lavenburg, New York City,	Geneva	G	50	———	†3.50
		Paris Green		F	57.04	30.84	3.09
1252	695	Leggett & Bro., New York City,	Albany	G	50	———	†3.50
		Paris Green		F	56.15	30.05	4.44
1354	695	Leggett & Bro., New York City,	Syracuse	G	50	———	†3.50
		Paris Green		F	56.12	30.16	4.14
1702	695	Leggett & Bro., New York City,	Batavia	G	50	———	†3.50
		Paris Green		F	56.25	30.13	3.21
1665	682	John Lucas & Co., New York City,	Naples	G	50	———	3.50
		Paris Green		F	56.21	29.76	2.47
1220	27	Morris Hermann Co., New York City,	Chatham	G	50	———	3.5
		Pure Paris Green		F	56.62	29.33	3.21
1857	27	Morris Hermann Co., New York City,	Wilson	G	50	———	3.5
		Pure Paris Green		F	56.78	29.44	3.33

1221	577	I. Pfeiffer, New York City, Paris Green	Chatham	G	50	——	3.50
				F	56.65	29.58	4.01
1875	2	C. T. Reynolds & Co., New York City, Paris Green	Gasport	G	57	——	——
				F	57.19	30.32	3.83
1233	607	Sherwin-Williams Co., New York City and Cleveland, O. Paris Green	Poughkeepsie	G	50	——	3.25
				F	56.65	30.48	4.20
1680	607	Sherwin-Williams Co., New York City and Cleveland, O. Paris Green	Spencerport	G	50	——	3.25
				F	56.59	30.49	4.05
1844	607	Sherwin-Williams Co., New York City and Cleveland, O. Paris Green	Newfane	G	50	——	3.25
				F	56.73	30.58	3.70

* G and F stand respectively for Guaranteed and Found. † Below.

LEAD ARSENATE.

Sample number.	Certificate number.	Name and address of manufacturer and trade name or brand.	Where taken.		Arsenic oxide.	Lead oxide.	Water-soluble arsenic.	Water.
					Per ct.	*Per ct.*	*Per ct.*	*Per ct.*
1843	874	A. B. Ansbacher & Co., New York City, Arsenate of Lead	Newfane	*G	——	——	——	——
				*F	16.96	34.55	0.46	46.28
1954	875	A. B. Ansbacher & Co., New York City, Arsenate of Lead	Waterport	G	15	35	0.50	——
				F	18.14	36.75	0.41	42.86
1201	201	Jas. A. Blanchard Co., New York City, Arsenate of Lead — Lion Brand	Tarrytown	G	——	——	——	——
				F	12.04	34.51	0.34	48.40
1973	201	Jas. A. Blanchard Co., New York City, Arsenate of Lead — Lion Brand	Albion	G	——	——	——	——
				F	11.71	33.53	0.47	50.27
1652	——	Corona Chemical Co., Arsenate of Lead — Dry	Geneva	G	30	63	0.75	0
				F	31	63.37	0.51	0

*G and F stand respectively for Guaranteed and Found.

LEAD ARSENATE — (*Continued*).

Sample number.	Certificate number.	Name and address of manufacturer and trade name or brand.	Where taken.		Arsenic oxide.	Lead oxide.	Water-soluble arsenic.	Water.
					Per ct.	*Per ct.*	*Per ct.*	*Per ct.*
1668	868	Devoe & Reynolds Co., New York City,	Canandaigua	*G	—	—	—	0
		Arsenate of Lead — Dry		*F	22	43.74	1.57	0
1967	—	Dow Chemical Co., Midland, Mich.,	Lyndonville	G	15	—	0.75	—
		Dow Arsenate of Lead		F	17.69	44.89	0.57	34.03
1869	660	Grasselli Chemical Co., Cleveland, O.,	Barker	G	15	—	0.50	50
		Arsenate of Lead Paste		F	17.36	38.89	1.35	41.51
1888	660	Grasselli Chemical Co., Cleveland, O.,	Middleport	G	15	—	0.50	50
		Arsenate of Lead Paste		F	16.63	38.47	Trace	43.19
1705	660	Grasselli Chemical Co., Cleveland, O.,	Batavia	G	13.5	34	0.50	—
		Arsenate of Lead — Wet		F	16.18	34.83	0.58	37.67
1923	481	Hemingway's London Purple Co., London, Eng., and New York City,	Lockport	G	15	32	0.50	—
		Pure Lead Arsenate		F	16.44	33.47	0.38	47.93
1886	—	Interstate Chemical Co., Jersey City, N. J.,	Newfane	G	15.50	—	—	50
		Arsenate of Lead		F	18.89	37.38	0.28	41.30
1663	489	F. L. Lavenburg, New York City,	Naples	G	17.36	32.58	—	—
		Arsenate of Lead		F	18.85	41.62	0.25	42.85
1861	489	F. L. Lavenburg, New York City,	Lockport	G	—	—	—	—
		Arsenate of Lead		F	14.44	30.59	0.38	52.44
1904	489	F. L. Lavenburg, New York City,	Lockport	G	—	—	—	—
		Arsenate of Lead		F	16.15	36.25	0.58	46.52
1906	489	F. L. Lavenburg, New York City,	Lockport	G	—	—	—	—
		Arsenate of Lead		F	14.31	30.82	0.30	53.79

1833	499	Leggett & Bro., New York City, Arsenate of Lead Paste	Buffalo	G	15	——	1	50
				F	14.68	33.44	0.51	49.12
1246	955	Merrimac Chemical Co., Boston, Mass., Arsenate of Lead	Albany	G	15	——	0.50	——
				F	15.75	33.96	0.55	36.36
1883	955	Merrimac Chemical Co., Boston, Mass., Arsenate of Lead	Lockport	G	15	——	0.50	——
				F	14.71	32.44	0.51	35.67
1901	409	Niagara Sprayer Co., Middleport, N. Y., Arsenate of Lead	Middleport	G	——	——	——	——
				F	17.93	35.05	0.43	45.84
1975	409	Niagara Sprayer Co., Middleport, N. Y., Arsenate of Lead	Albion	G	15	——	0.75	——
				F	16.42	32.64	0.25	49.06
1884	649	Powers-Weightman, Rosengarten Co., New York and Philadelphia, Pa.	Lockport	G	12.5	39	0.75	——
				F	10.97	31.3	0.45	51.71
1225	969	Rex Co. (Distributors), Rochester, Arsenate of Lead	Germantown	G	15	32	0.50	——
				F	17.77	34.38	0.24	45.75
1893	566	Riches-Pivers Co., R. P. & Co. Arsenate of Lead	Lockport	G	15	33	0.50	——
				F	15.81	31.24	0.38	51.23
1234	607	Sherwin-Williams Co., New York City, Arsenate of Lead	Poughkeepsie	G	12.5	——	0.75	——
				F	12.15	34.28	0.73	48.70
1700	113	Thomsen Chemical Co., Baltimore, Md., Arsenate of Lead — Orchard Brand	Batavia	G	——	——	——	——
				F	12.67	35.50	0.62	49.37
1713	113	Thomsen Chemical Co., Baltimore, Md., Arsenate of Lead	Wilson	G	15	——	0.75	——
				F	12.35	28.73	0.70	55.52
1504	656	Vreeland Chemical Co., Rochester, Arsenate of Lead — Dry	Rochester	G	31	——	0.67	0
				F	30.26	64.40	0.29	0
1505	655	Vreeland Chemical Co., Rochester, Arsenate of Lead Paste	Rochester	G	20	——	0.33	40
				F	19.72	39.13	0.26	39.87

*G and F stand respectively for Guaranteed and Found.

BORDEAUX MIXTURE.

Sample number.	Certificate number.	Name and address of manufacturer and trade name or brand.	Where taken.		Copper (Cu).
					Per ct.
1247	878	A. B. Ansbacher & Co., New York City, Bordeaux Mixture	Albany	*G *F	8.47 12.37
1848	200	Jas. A. Blanchard Co., New York City, Lion Brand Bordeaux Mixture	Buffalo	G F	4 4.45
1240	593	Benj. Hammond, Fishkill, N. Y., Bordeaux Mixture (Pulp)	Fishkill	G F	5.46 6.46
1214	591	Hammond's Paint & Slug Shot Works, Fishkill, N. Y., French Bordo Mixture	Tarrytown	G F	8.17 5.86
1835	511	Leggett & Bro., New York City, Bordeaux Mixture	Buffalo	G F	11.18 11.49
1258	608	Sherwin-Williams Co., Cleveland, Ohio, and New York City Bordeaux Mixture	Troy	G F	6.52 7.60
1351	———	Sterling Chemical Co., Cambridge, Mass., Bordeaux Mixture — Dry	Syracuse	G F	——— 12.56
1910	———	Thomsen Chemical Co., Baltimore, Md., Bordeaux Mixture	Lockport	G F	9 9.05
1203	———	Vaughan's Seed Store (Wholesaler), New York City, Bordeaux Mixture	Tarrytown	G F	12.70 13.16

*G and F stand respectively for Guaranteed and Found

BORDEAUX-PARIS GREEN MIXTURE.

Sample number.	Certificate number.	Name and address of manufacturer and trade name or brand.	Where taken.		Copper (Cu).	Arsenious oxide.	Water-soluble arsenious oxide.
					Per ct.	*Per ct.*	*Per ct.*
1259	——	Bowker Insecticide Co., Boston, Mass.,	Troy	*G	——	——	——
		Boxal		*F	12.08	13.52	——
1238	——	Benj. Hammond, Fishkill, N. Y.,	Fishkill	G	5.46	——	——
		Bordeaux Mixture with Paris Green		F	4.87	0.22	——
1251	509	Leggett & Bro., New York City,	Albany	G	15	17.15	3
		Bordeaux Mixture Dry and Paris Green		F	16.02	16.86	3.10
1831	509	Leggett & Bro., New York City,	Buffalo	G	——	——	——
		Bordeaux Mixture Dry and Paris Green		F	19.22	16.48	2.74

BORDEAUX-LEAD ARSENATE MIXTURE.

Sample number.	Certificate number.	Name and address of manufacturer and trade name or brand.	Where taken.		Arsenic oxide.	Lead oxide.	Copper (Cu).	Water-soluble arsenic oxide.	Water.
					Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1897	877	A. B. Ansbacher & Co., New York City,	Appleton	*G	7	15	2.6	1.50	——
		Pyro-Bordo-Lead		*F	12.19	26.23	3.47	0.43	48.71
1918	697	Bowker Insecticide Co., New York City,	Lockport	G	6.75	17	1.6	0.40	——
		Pyrox		F	6.95	14.72	1.77	0.39	66.15

*G and F stand respectively for Guaranteed and Found.

BORDEAUX-LEAD ARSENATE MIXTURE—*(Continued)*

Sample number.	Certificate number.	Name and address of manufacturer and trade name or brand.	Where taken.		Arsenic oxide.	Lead oxide.	Copper (Cu).	Water-soluble arsenic oxide.	Water.
					Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1852	665	Grasselli Chemical Co., Cleveland, O., Bordeaux Lead Arsenate Mixture Paste	Buffalo	*G	3.98	——	3.6	0.10	——
				*F	4.67	10.16	5.65	0.11	47.19
1239	593	Benj. Hammond, Fishkill, N. Y., Bordeaux Mixture with Arsenate of Lead	Fishkill	G	0.95	2.21	——	——	——
				F	1.30	2.73	2.59	——	51.26
1699	262	Thomsen Chemical Co., Baltimore, Md., Bordeaux Arsenate of Lead	Batavia	G	——	——	——	——	——
				F	2.82	5.90	2.37	——	71.74
1685	——	L. J. Waldock, Bordo Compound	Brockport	G	——	——	——	——	——
				F	13.27	25.60	2.80	——	59.69

LIME-SULPHUR SOLUTION.

Sample number.	Certificate number.	Name and address of manufacturer and trade name or brand.	Where taken.		Sulphur in solution.	Density.	Sediment
					Per ct.	*Degs. B.*	*Per ct.*
1228	199	Jas. Blanchard Co., New York City, Lime-Sulphur Solution	Germantown	*G	20	——	——
				*F	24.10	31.4	0.2
1227	696	Bowker Mfg. Co., Boston and New York City, Lime-Sulphur Solution	Germantown	G	26	33	——
				F	26.34	33.3	0

1951	625	A. Copstick, Albion, N. Y., Lime-Sulphur	Albion	G	——	30	——
				F	19.61	28.1	0.77
1889	863	J. L. Cramer, Middleport, N. Y., Cherry Brand Lime-Sulphur	Middleport	G	——	——	——
				F	22.17	29.4	0.42
1672	——	Dow Chemical Co., Midland, Mich., Lime-Sulphur Solution	Canandaigua	G	25.5	33	——
				F	26.06	32.7	0
1890	702	Downicide Chem. Co., Middleport, N. Y., Lime-Sulphur Solution	Middleport	G	——	28	——
				F	24.27	30.9	0.38
1891	702	Downicide Chem. Co., Middleport, N. Y., Lime-Sulphur Solution	Middleport	G	——	——	——
				F	22.82	31.0	17.26
1903	702	Downicide Chem. Co., Middleport, N. Y., Lime-Sulphur Solution	Middleport	G	——	31	——
				F	24.11	30.6	0.64
1692	627	W. W. Dufloo, Sodus, N. Y., Lime-Sulphur Solution	Webster	G	——	28	——
				F	21.02	28.6	0.91
1868	858	H. A. Ernest, Lockport, N. Y., Chestnut Brand Lime-Sulphur Solution	Gasport	G	——	——	——
				F	20.04	29.2	0
1217	609	Henry Finger, Germantown Lime-Sulphur Solution	Chatham	G	24	——	——
				F	24.62	31.5	0
1953	——	Geo. Fuller, Waterport, N. Y., Lime-Sulphur	Waterport	G	——	——	——
				F	17.33	28.1	7.14
1229	666	Grasselli Chemical Co., Cleveland, O., and New York City Lime-Sulphur Solution	Germantown	G	——	——	——
				F	25.01	32.7	0
1669	666	Grasselli Chemical Co., Cleveland, O., and New York City Lime-Sulphur Solution	Victor	G	25	33	——
				F	25.45	32.1	0
1706	666	Grasselli Chemical Co., Cleveland, O., and New York City Lime-Sulphur Solution	Batavia	G	25	33	——
				F	25.14	31.4	0.27
1801	666	Grasselli Chemical Co., Cleveland, O., and New York City Lime-Sulphur Solution	Youngstown	G	25	33	——
				F	25.27	33	0

*G and F stand respectively for Guaranteed and Found

LIME-SULPHUR SOLUTION—(*Continued*)

Sample number.	Certificate number.	Name and address of manufacturer and trade name or brand.	Where taken.		Sulphur in solution.	Density.	Sediment
					Per ct.	*Degs. B.*	*Per ct.*
1870	666	Grasselli Chemical Co., Cleveland, O.,	Barker	*G	25	33	——
		Lime-Sulphur Solution		*F	24.16	31.4	0.72
1958	666	Grasselli Chemical Co., Cleveland, O.,	Knowlesville	G	25	33	——
		Lime-Sulphur Solution		F	24.92	32.6	0
1241	49	Benj. Hammond, Fishkill, N. Y.,	Fishkill	G	——	40	——
		Lime-Sulphur and Salt		F	25.12	36.5	——
1242	898	Benj. Hammond, Fishkill, N. Y.,	Fishkill	G	21	32	——
		Lime-Sulphur		F	25.88	33.2	0
1879	882	Arthur Hayes, Gasport, N. Y.,	Gasport	G	——	——	——
		Lime-Sulphur Solution		F	21.02	31.3	17.21
1830	497	Leggett & Bro., New York City,	Buffalo	G	25	33	——
		Anchor Brand Lime-Sulphur Solution		F	26.26	33.4	0
1264	331	L. L. Morrell, Kinderhook, N. Y.,	Kinderhook	G	——	26	——
		Lime-Sulphur Solution		F	16.09	24.7	6.21
1670	415	Niagara Sprayer Co., Middleport, N. Y.,	Holcomb	G	25	32	——
		Lime Sulphur Solution		F	25.62	33.1	4.70
1684	415	Niagara Sprayer Co., Middleport, N. Y.,	Brockport	G	25	32	——
		Lime Sulphur Solution		F	25.17	32.7	0
1804	415	Niagara Sprayer Co., Middleport, N. Y.,	Lockport	G	25	32	——
		Lime Sulphur Solution		F	24.91	32	0
1216	——	T. F. Niles, Chatham, N. Y.,	Spencertown	G	——	——	——
		Lime-Sulphur Solution		F	21.52	29.9	0

1508	359	Dr. Ottoway,	Charlotte	G	——	24	——
		Lime-Sulphur		F	13	21.6	0.42
1673	720	J. A. Page, Phelps, N. Y.,	Phelps	G	16	24	——
		Lime-Sulphur Solution		F	16.17	22.8	0.25
1820	854	C. A. Perrigo, Burt, N. Y.,	Newfane	G	——	——	——
		Ashland Brand Lime-Sulphur Solution		F	21.05	29.3	2.30
1825	854	C. A. Perrigo, Burt, N. Y.,	Lockport	G	——	——	——
		Ashland Brand Lime-Sulphur Solution		F	22.02	30.5	31.65
1912	854	C. A. Perrigo, Burt, N. Y.,	Burt	G	——	——	——
		Ashland Brand Lime-Sulphur Solution		F	21.72	29.8	19.30
1913	854	C. A. Perrigo, Burt, N. Y.,	Burt	G	——	——	——
		Ashland Brand Lime-Sulphur Solution		F	22.20	30.6	10.70
1914	854	C. A. Perrigo, Burt, N. Y.,	Burt	G	——	——	——
		Ashland Brand Lime-Sulphur Solution		F	22.47	30.8	17.50
1226	968	Rex Co., Rochester, N. Y.,	Germantown	G	25	33	——
		Lime-Sulphur		F	25.01	31.8	0.87
1507	968	Rex Co., Rochester, N. Y.,	Rochester	G	25	33	——
		Lime-Sulphur		F	26.42	33.3	0
1661	968	Rex Co., Rochester, N. Y.,	Seneca Castle	G	——	32	——
		Lime-Sulphur		F	24.92	31.5	0
1676	376	W. H. Robinson & Son, Flint, N. Y.,	Flint	G	——	29	——
		Lime-Sulphur Solution		F	20.34	28.10	0.10
1907	266	Geo. J. Rounds, Lockport, N. Y.,	Lockport	G	——	32	——
		Climax Lime-Sulphur Solution		F	22.11	30.5	0
1908	266	Geo. J. Rounds, Lockport, N. Y.,	Lockport	G	——	——	——
		Climax Lime-Sulphur Solution		F	22.03	29.6	2.47
1909	266	Geo. J. Rounds, Lockport, N. Y.,	Lockport	G	——	33	——
		Climax Lime-Sulphur Solution		F	23.06	31.3	1.60
1671	324	Salisbury Bros., Phelps, N. Y.,	Phelps	G	——	24	——
		Lime-Sulphur Solution		F	16.36	24.8	1.15

*G and F stand respectively for Guaranteed and Found.

LIME-SULPHUR SOLUTION — (*Concluded*)

Sample number.	Certificate number.	Name and address of manufacturer and trade name or brand.	Where taken.		Sulphur in solution.	Density.	Sediment
					Per ct.	*Degs. B.*	*Per ct.*
1822	——	Smith & Davis,	Lockport	*G	——	——	——
		Crescent Lime-Sulphur		*F	20.81	28.9	0.15
1823	——	Smith & Davis,	Lockport	G	——	——	——
		Crescent Lime-Sulphur		F	21.31	29.60	10.70
1866	——	Sterling Chemical Co., Cambridge, Mass.,	Lockport	G	——	32	——
		Sterlingworth Lime-Sulphur Wash		F	23.69	31.3	0
1811	337	F. H. Taylor & Son, Lockport, N. Y.,	Lockport	G	——	30	——
		Lime-Sulphur		F	18.72	27.4	43.55
1816	337	F. H. Taylor & Son, Lockport, N. Y.,	Lockport	G	——	——	——
		Lime-Sulphur		F	19.41	27.5	0.15
1244	114	Thomsen Chemical Co., Baltimore, Md.,	Albany	G	24	32	——
		Lime-Sulphur Solution		F	25.02	31.5	0.61
1675	114	Thomsen Chemical Co., Baltimore, Md.,	Seneca	G	24	32	——
		Lime-Sulphur Solution		F	24.83	31.4	0.10
1921	114	Thomsen Chemical Co., Baltimore, Md.,	Lockport	G	24	32	——
		Lime-Sulphur Solution		F	24.62	31.5	0.48
1711	865	H. B. Treichler, Sanborn, N. Y.,	Sanborn	G	——	32	——
		Lime-Sulphur Solution		F	21.98	29.9	0
1502	659	Vreeland Chemical Co., Little Falls, N. Y.,	Rochester	G	24.5	32.5	——
		Lime-Sulphur Solution		F	25.47	32.7	0
1674	834	John Wells, Shortsville, N. Y.,	Shortsville	G	——	30	——
		Lime-Sulphur Solution		F	22.30	30.3	10.75

1915	844	Wilson & Capen, Lockport, N. Y., W. & C. Brand Lime-Sulphur Solution	Burt	G	—	—	—
				F	20.82	29.9	0.50
1917	844	Wilson & Capen, Lockport, N. Y., W. & C. Brand Lime-Sulphur Solution	Lockport	G	—	—	—
				F	21.04	29.6	0.29

*G and F stand respectively for Guaranteed and Found.

SOLUBLE SULPHUR COMPOUNDS.

Sample number.	Certificate number.	Name and address of manufacturer and trade name or brand.	Where taken.		Soluble sulphur.
					Per ct.
1666	713	Niagara Sprayer Co., Middleport, N. Y.,	Canandaigua	*G	58
		Soluble Sulphur Solution		*F	58.42
1806	713	Niagara Sprayer Co., Middleport, N. Y.,		G	———
		Soluble Sulphur Solution		F	58.92
1885	713	Niagara Sprayer Co., Middleport, N. Y.,	Olcott	G	57
		Soluble Sulphur Solution		F	58.16
1900	713	Niagara Sprayer Co., Middleport, N. Y.,	Middleport	G	58
		Soluble Sulphur Solution		F	58.00

MIXTURE OF SOLUBLE SULPHUR AND OILS.

Sample number.	Certificate number.	Name and address of manufacturer and trade name or brand.	Where taken.		Soluble sulphur.
					Per ct.
1210	———	Aphine Mfg. Co., Madison, N. J.,	Tarrytown	*G	———
		Fungine		*F	4.95
1694	648	Charles Fremd, North Rose, N. Y.,	North Rose	G	———
		Sulco-V-B-(Sulphur Compound)		F	7.82
1362	523	B. G. Pratt, New York City,	Auburn	G	———
		Sulfocide		F	31.81

*G and F stand respectively for Guaranteed and Found

NICOTINE PREPARATIONS.

Sample number.	Certificate number.	Name and address of manufacturer and trade name or brand.	Where taken		Nicotine.
					Per ct.
1211	——	Aphine Mfg. Co., Madison, N. J., Aphine	Tarrytown	*G	0.90
				*F	0.89
1208	——	Jas. A. Blanchard, New York City, Powdered Tobacco	Tarrytown	G	——
				F	0.98
1205	437	Hammond's Slug-Shot Works, Fishkill, N. Y., Tobacco Extract	Tarrytown	G	4
				F	4.65
1503	——	Kentucky Tobacco Product Co., Louisville, Ky. Black-Leaf 40	Rochester	G	40
				F	43.52
1845	——	Kentucky Tobacco Product Co., Louisville, Ky., Nico-fume	Buffalo	G	40
				F	44.94
1853	——	Parke Davis & Co., Detroit, Mich., Nicotine	Wilson	G	10
				F	10.03
1222	——	Parke Davis & Co., Detroit, Mich., Nictone	Chatham	G	——
				F	9.87
1223	——	Parke Davis & Co., Detroit, Mich., Rose Nicotine	Chatham	G	10
				F	11.19
1207	838	H. A. Stoothoff Co., Mt. Vernon, N. Y., Tobacco Naphtholene Mixture	Tarrytown	G	0.50
				F	1.02
1701	——	F. A. Thompson Co., Detroit, Mich., Rose Nicotine	Batavia	G	10
				F	9.92
1206	929	Vaughan's Seed Store (Dealer), New York City, Nikoteen	Tarrytown	G	30
				F	32.85

*G and F stand respectively for Guaranteed and Found.

SOAP.

Sample number.	Certificate number.	Name and address of manufacturer and trade name or brand	Where taken.		Water.	Water-free soap.	Combined fatty acids and resin.	Combined alkali	Free caustic alkali.	Unsaponified matter.	Nicotine.
					Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1678	——	Jas. Good, Philadelphia, Pa.,	Victor	*G	——	——	——	——	——	——	——
		Whale-Oil Soap		*F	8.94	91.06	81.00	10.06	0.33	——	——
1812	——	Jas. Good, Philadelphia, Pa.,	Gasport	G	——	——	47	——	——	——	——
		Fish-Oil Soap		F	46.98	53.02	46.96	6.06	——	——	——
1847	——	Jas. Good, Philadelphia, Pa.,	Buffalo	G	——	——	——	8	——	——	3
		Fish-Oil Soap		F	52.01	44.86	37.26	7.60	0.31	3.13	3.13
1878	——	Jas. Good, Philadelphia, Pa.,	Gasport	G	——	——	——	7	——	——	——
		Fish-Oil Soap		F	16.28	80.75	72.04	8.71	——	2.97	——
1237	432	Benj. Hammond, Fishkill, N. Y.,	Fishkill	G	——	37.70	——	7.80	——	——	0.12
		Thrip Juice		F	53.06	41.89	32.46	9.43	——	5.05	0.47
1257	485	Larkin Co., Buffalo, N. Y.,	Albany	G	——	——	——	——	——	——	——
		Sulpho-Tobacco Soap		F	12.88	76.41	68.10	8.31	——	10.71	0.66
1256	508	Leggett and Bro., N. Y. City,	Albany	G	——	81	——	——	0.50	——	——
		Fish-Oil Soap		F	10.34	61.33	54.23	7.10	——	28.33	——
1664	508	Leggett and Bro., N. Y. City,	Naples	G	——	——	——	7	——	——	——
		Fish-Oil Soap		F	8.61	64.89	57.35	7.54	——	26.50	——
1253	541	J. C. Pierson	Albany	G	——	——	——	——	——	——	——
		Fir-Tree Oil Soap		F	28.74	66.25	59.15	7.10	0.18	†5.01	——

1254	—	Sterling Chem. Co., Cambridge, Mass., Fish-Oil Soap with Tobacco	Albany	G	—	—	—	—	—	—	—
				F	11.28	48.28	43.62	4.66	—	40.44	—
1248	232	Walker & Gibson, Albany, N. Y., Fish-Oil Soap	Albany	G	—	—	—	9	—	—	—
				F	9.90	87.98	78.53	9.45	—	2.12	—

*G and F stand respectively for Guaranteed and Found. † Largely carbolic acid (phenol)

HELLEBORE.

Sample number.	Certificate number.	Name and address of manufacturer and trade name or brand.	Where taken.		Ash.
					Per ct.
1204	——	Jas. A. B. Blanchard Co., New York City, Powdered Hellebore—Strictly Pure	Tarrytown	*G	——
				*F	15.19
1353	——	Jas. A. Blanchard Co., New York City, Hellebore	Syracuse	G	——
				F	21.45
1698	——	Ellicott Drug Co., Buffalo, N. Y., Hellebore	Batavia	G	——
				F	14.22
1659	166	Gibson Drug Co., Rochester, N. Y., Hellebore	Seneca Castle	G	——
				F	14.52
1877	166	O. J. Givens, Gasport, N. Y., Hellebore	Gasport	G	——
				F	10.96
1215	——	E. F. Jones Chemical Co., New York City, Powdered Hellebore — Pure	Tarrytown	G	——
				F	13.05
1255	505	Leggett & Bro., New York City, Hellebore — Pure	Albany	G	——
				F	15.44
1836	505	Leggett & Bro., New York City, Hellebore — Pure	Buffalo	G	——
				F	10.17
1840	505	Leggett & Bro., New York City, Hellebore — Pure	Buffalo	G	——
				F	9.73
1841	505	Leggett & Bro., New York City, Hellebore — Pure	Buffalo	G	——
				F	9.63
1862	166	Parsons Drug Co., Lockport, N. Y., Hellebore	Lockport	G	——
				F	10.60
1249	164	Walker & Gibson, Albany, Hellebore — Pure	Albany	G	——
				F	14.46

*G and F stand respectively for Guaranteed and Found.

MISCELLANEOUS MATERIALS AND MIXTURES.

Sample number.	Certificate number.	Name and address of manufacturer and trade name or brand.	Where taken.	
1211	——	Aphine Mfg. Co., Madison, N. J., Aphine	Tarrytown	"Aphine" contains .90 per ct. nicotine mixed with vegetable oils (cedar and pine) and caustic potash.
1854	——	Am. Hort. Distributing Co., Martinsburg, W. Va., Potato Scab Destroyer	Wilson	A solution of formaldehyde, artificially colored.
1849	——	Jas. A. Blanchard, N. Y. City, Lion Brand Kerosene Emulsion	Buffalo	A kerosene emulsion.
1838	711	Dewane Bogue, Medina, N. Y., New Insect Destroyer	Buffalo	Largely kerosene oil.
1262	——	Danforth Chemical Co., Leominster, Mass., Bug Death	Troy	Contains 46.68 per ct. zinc oxide and 5.59 per ct. lead oxide.
1920	694	The Gardiner-Johns Co., Rochester, N. Y., San-U-Zay Scale Oil	Lockport	Largely a mixture of mineral and animal oils.
1243	430	Benj. Hammond, Fishkill, N. Y., Slug-Shot	Fishkill	Contains free sulphur, copper sulphate, tobacco, calcium sulphate, copper arsenite, and crude carbolic acid.
1218	——	Hemingway London Purple Co., London and New York, Caasen	Chatham	Contains 34.13 per ct. arsenic oxide and 8.10 per ct. copper.

MISCELLANEOUS MATERIALS AND MIXTURES — *(Continued)*.

Sample number.	Certificate number.	Name and address of manufacturer and trade name or brand.	Where taken.	
1856	707	Morris Herrmann & Co., N. Y. City, Arsite	Wilson	Contains 72.82 per ct. water-soluble arsenious oxide.
1855	708	Morris Herrmann & Co., N. Y. City, Calite	Wilson	Contains 34.37 per ct. arsenious oxide, 1.48 per ct. being water-soluble.
1894	———	Horticultural Chemical Co., Philadelphia, Pa., Target Brand Scale Destroyer	Lockport	A miscible oil.
1260	———	Lemon Oil Co., Baltimore, Md., Standard Insecticide	Troy	Contains 87.22 per ct. water and volatile matter. Residue is largely fatty acids and resin, saponified with potassium carbonate.
1213	525	B. G. Pratt Co., N. Y. City, Scalecide	Tarrytown	A mixture of mineral and vegetable oils with naphthalene.
1212	525	B. G. Pratt & Co., Plant Oil	Tarrytown	Largely vegetable oils.
1707	558	H. J. Smith & Co., Utica, N. Y., Simplex	Batavia	Contains 8.92 per ct. lead oxide, 5.25 per ct. arsenic oxide, and 20.84 per ct. sulphur.

INSPECTION OF FEEDING STUFFS.†

This bulletin gives the results of the analyses[1] of samples of feeding stuffs collected by the Commissioner of Agriculture during the fall and winter of 1913–14 and by him transmitted for analysis to the Director of the New York Agricultural Experiment Station, in accordance with the provisions of Article VII of the Agricultural Law. These analyses are published by the Director of the New York Agricultural Experiment Station in accordance with the provisions of section 164 of said article.

ANALYSES OF SAMPLES OF FEEDING STUFFS.

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.
			Per ct.	*Per ct.*	*Per ct.*
	COTTONSEED MEALS:				
5521	The American Cotton Oil Co., Jackson, Tenn. "Choice Cottonseed Meal"	Ellicottville	G* 41. F* 37.6	9. 7.4	10.50 9.5
6440	The American Cotton Oil Co., Albany, Ga. "Prime Cotton Seed Meal"	W. Coxsackie	G 38.61 F 39.8	8. 8.9	11.50 10.2
3892	The American Cotton Oil Co., New York, N. Y. "Red Tag Cotton Seed Meal"	Patterson	G 38.55 F 39.3	7. 6.8	11.50 10.8
6105	M. F. Baringer, Philadelphia, Pa. "Prime Cotton Seed Meal"	S. New Berlin	G 38.62 F 40.6	6. 6.7	10. 11.
5629	F. W. Brode & Co., Memphis, Tenn. "Owl Brand High Grade Cotton Seed Meal"	Troy	G 41. F 41.4	6. 7.95	10. 8.3
6122	F. W. Brode & Co., Memphis, Tenn. "Cub Brand Prime Cotton Seed Meal"	Solsville	G 40. F 37.8	6. 6.6	10. 9.8
5481	F. W. Brode & Co., Memphis, Tenn. "Dove Brand Cotton Seed Meal"	Buffalo	G 38.62 F 38.6	6. 6.94	10. 10.1

* These letters indicate, respectively, Guaranteed and Found.

† Reprint of Bulletin No. 386, May.

[1] The analyses herewith published were made in charge of the Chemical Department of the Station, the immediate oversight of the work being assigned to E. L. Baker, Associate Chemist, since resigned.

ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.
			Per ct.	*Per ct.*	*Per ct.*
	COTTONSEED MEALS (*concluded*):				
6454	F. W. Brode & Co., Memphis, Tenn. "Fox Brand Standard Cotton Seed Feed"	Cooperstown	G* 22. F* 20.2	5. 4.	28. 21.6
5488	Buckeye Cotton Oil Co., Cincinnati, O. "Buckeye Prime Cotton Seed Meal"	Buffalo	G 38.62 F 38.7	6.50 6.37	12. 11.4
5796	S. P. Davis, Little Rock, Ark. "Good Luck Brand Cotton Seed Meal"	Tully	G 41. F 40.5	7. 7.4	10.50 9.5
5756	Humphreys Godwin Co., Memphis, Tenn. "Dixie Brand Cottonseed Meal"	Hooper	G 38.62 F 39.4	6. 6.6	12. 11.8
5540	Humphreys Godwin Co., Memphis, Tenn. "Forfat Brand"	Medina	G 38.62 F 38.9	6. 8.6	12. 10.9
5480	Imperial Cotto Milling Co., Memphis, Tenn. "Imperial Cotto Brand Choice Cotton Seed Meal"	Buffalo	G 41. F 40.9	8. 7.94	9. 8.
6126	Imperial Cotto Milling Co., Memphis, Tenn. "Imperial Cotto Brand Prime Cotton Seed Meal"	Eaton	G 38.62 F 40.9	7. 8.7	12. 10.
6194	W. C. Nothern, Little Rock, Ark. "Bee Brand Cotton Seed Meal Cake"	Matteawan	G 41. F 40.3	6. 7.1	10. 9.1
6456	Geo. B. Robinson, Jr., New York, N. Y. "Robin Bran Cotton Seed Meal"	Oneonta	G 41. F 41.	6. 7.3	10. 9.3
6306	W. Newton Smith, Baltimore, Md. "Dirigo Brand Cotton Seed Meal"	Union Springs	G 41. F 38.6	7. 7.1	10.50 10.1
6058	Southern Cotton Oil Co., Charlotte, N. C. "Bonita Brand Cotton Seed Meal"	Brooklyn	G 38.62 F 40.5	6. 7.4	10. 9.3
6079	J. Lindsay Wells Co., Memphis, Tenn. "Sun Brand Prime Finely Ground Cotton Seed Meal"	Riverhead	G 41. F 40.9	7. 11.2	10. 10.

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Samples of Feeding Stuffs (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.
			Per ct.	*Per ct.*	*Per ct.*
	Cottonseed Feed:				
5661	Tennessee Fibre Co., Memphis, Tenn. " Creamo Brand Cotton Seed Feed "†	Stamford	G* 20. F* 21.3	5. 3.8	22. 20.3
	Linseed Meals:				
6012	American Milling Co., Chicago, Ill. " Amco Old Process Linseed Meal "	Auburn	G 32. F 32.6	6. 6.5	11. 8.6
5530	American Linseed Co., Chicago, Ill. " Linseed Oil Meal "	Olean	G 36. F 35.6	2. 2.4	9. 8.8
5956	American Linseed Co., New York, N. Y. " Old Process Oil Meal "	Attica	G 34. F 34.1	5. 5.8	8. 8.2
4928	American Linseed Co., New York, N. Y. " Old Process Oil Meal "	Geneva	G 34. F 34.1	5. 5.81	8. 8.5
6124	Archer-Daniels Linseed Co., Minneapolis, Minn. " Old Process Ground Oil Cake "	Morrisville	G 32. F 35.8	6. 7.	10. 7.5
6031	Hauenstein & Co., Buffalo, N. Y. "Old Process Linseed Meal"	Bergen	G 30. F 33.	5. 6.5	10. 8.7
5502	The Guy G. Major Co., Toledo, O. " Old Process Oil Meal "	South Dayton	G 30. F 33.2	5. 7.5	10. 8.5
5473	The Mann Bros. Co., Buffalo, N. Y. " Pure Old Process Linseed Oil Meal "	Buffalo	G 34. F 33.4	6. 7.52	10. 7.9
6018	Kelloggs & Miller, Amsterdam, N. Y. " Pure (Old Process) Oil Meal "	Canandaigua	G 33. F 34.7	5. 7.4	7.5 7.8
5610	Kelloggs & Miller, Amsterdam, N. Y. " Pure (Old Process) Oil Meal."	Albany	G 32. F 33.4	4. 6.1	9. 8.
6063	Laxo Cake Meal Co., Chicago, Ill. " Old Process Laxo Cake Meal "‡	Brooklyn	G 25. F 25.6	6. 9.6	12. 9.8

* These letters indicate, respectively, Guaranteed and Found.
† Guaranteed, cottonseed meal and cottonseed hull bran. Found, cottonseed meal and cottonseed hulls.
‡ Guaranteed, crude flax seed with the ordinary field seeds. Found, linseed meal, ground screenings (weed seeds).

ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.
			Per ct.	*Per ct.*	*Per ct.*
	LINSEED MEALS (*concluded*):				
6002	The Metzger Seed & Oil Co., Toledo, O "Old Process Oil Meal"	Auburn	G* 30. F* 32.1	5. 7.13	10. 8.2
5616	Midland Linseed Products Co., Minneapolis, Minn. "Old Process Ground Linseed Cake"	Albany	G 32. F 32.	5. 7.0	9.5 7.5
6557	National Feed Co., St Louis, Mo. "Pure Old Process Linseed Meal"	Malone	G 34. F 34.5	7. 8.5	7. 7.2
6092	Purabla Oil Co., Blue Point, L. I. "Purabla Oil Meal" ‡	Blue Point	G 30. F 40.9	15. 21.3	5. 2.3
6131	The Sherwin Williams Co., Cleveland, O. "Linseed Oil Meal"	Syracuse	G 33. F 36.5	6. 8.5	8. 7.4
5498	The Toledo Seed & Oil Co., Toledo, O. "Major Brand Old Process Oil Meal"	South Dayton	G 30. F 32.4	5. 6.9	10. 8.5
5665	The Toledo Seed & Oil Co., Toledo, O. "Major Brand Old Process Oil Meal"	Downsville	G 30. F 31.2	5. 6.7	10. 9.3
5758	The Toledo Seed & Oil Co., Toledo, O. "Major Brand Old Process Oil Meal"	Binghamton	G 30. F 31.1	5. 7.4	10. 8.5
5556	The Toledo Seed & Oil Co., Toledo, O. "Old Process Oil Meal"	Chatham	G 30. F 30.8	5. 6.7	10. 8.9
	MALT SPROUTS:				
6064	American Malting Co., New York, N. Y. "Hully Malt sprouts"§	New York	G 4.7 F 17.9	1.02 1.5	31.81 15.8
5648	American Malting Co., Buffalo, N. Y. "Malt Sprouts"	Kinderhook	G 15.63 F 26.1	1.54 1.6	15.70 11.9
5513	H. G. Anderson & Co., Buffalo, N. Y. "Malt sprouts"	Buffalo	G —— F 24.	—— 1.9	—— 10.9

* These letters indicate, respectively, Guaranteed and Found.
‡ Found, sesame oil meal.
§ Found, malt sprouts, malted barley, barley hulls.

Analyses of Samples of Feeding Stuffs (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.
			Per ct.	*Per ct.*	*Per ct.*
	Malt Sprouts (*concluded*):				
5482	Atlantic Export Co., of Wis. Chicago, Ill. "Malt Sprouts"	Buffalo	G* 22. F* 25.6	1. 2.16	16. 9.6
6424	P. Ballantine & Sons, Newark, N. J. "Malt Sprouts"†	Chester	G 25.63 F 25.8	1.47 2.1	13.40 9.4
6431	M. F. Baringer, Philadelphia, Pa. "Malt Sprouts"	Middletown	G 25. F 26.1	1.60 2.3	13. 10.7
6070	Farmers Feed Co., New York, N. Y. "Malt Sprouts"‡	New York	G 26.06 F 27.4	1.57 2.8	12.95 9.8
6169	Geneva Malting Co., Geneva, N. Y. "Malt Sprouts"	Poughkeepsie	G 25.50 F 26.8	2.40 2.	10.49 11.2
5494	John Kam Malting Co., Buffalo, N. Y. "Malt Sprouts"	North Collins	G 25. F 25.8	.75 1.5	16. 13.2
6333	Lembeck & Betz Eagle Brewing Co., Watkins, N. Y. "Malt Sprouts"	Watkins	G 28.30 F 30.5	1.12 1.4	13.31 9.2
5546	Geo. J. Meyer Malting Co., Buffalo, N. Y. "Malt Sprouts"	Buffalo	G 20.82 F 29.9	1.4 1.6	14. 12.6
5483	Henry C. Moffat, Buffalo, N. Y. "Malt Sprouts"	Buffalo	G 25. F 24.9	1.6 1.70	12. 12.2
6203	Perot Malting Co., Buffalo, N. Y. "Malt Sprouts"	Buffalo	G 23. F 26.9	.50 1.5	18. 12.3
5637	M. G. Rankin & Co., Milwaukee, Wis "Jersey Malt Sprouts"	Albany	G 25. F 25.6	1.50 1.6	17. 10.8
6205	Albert Schwill & Co., Buffalo, N. Y. "Malt Sprouts"	Buffalo	G 23.70 F 27.5	1. 1.3	14. 12.2
5491	The C. Zwickel Malting Co., Buffalo, N. Y. "Malt Sprouts"	East Aurora	G 25. F 27.4	2. 1.8	11. 12.5

* These letters indicate, respectively, Guaranteed and Found.
† Contains screenings (largely whole weed seeds).
‡ Contains weed seeds.

ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.
			Per ct.	*Per ct.*	*Per ct.*
	DISTILLERS' DRIED GRAINS:				
5753	Ajax Milling & Feed Co., New York, N. Y. "Ajax Flakes"†	Owego	G* 30. F* 30.1	11. 10.7	14. 10.7
5639	Atlantic Export Co. of Wis., Chicago, Ill. "Atlantic Grains"†	Albany	G 28. F 29.2	6. 8.7	14. 9.
5951	Geo. E. Brisbin & Co., Clyde, N. Y. "Argood Dried Distillery Grains"‡	Attica	G 26. F 27.6	9. 14.4	12. 6.8
6160	Clarke Bros. & Co., Peoria, Ill. "Empire State Dairy Feed"†	Mechanicville	G 30. F 31.7	12. 10.9	12. 11.5
6312	Columbia Distilling Co., Waterloo, N. Y. "Distillers Dried Grains"†	Waterloo	G 25. F 32.1	8. 12.6	14. 9.9
5983	The Dewey Bros. Co., Blanchester, O. "Bourbon 3 D Grains"†	Java Village	G 24. F 27.1	8. 9.2	14. 10.4
5768	The Dewey Bros. Co., Blanchester, O. "Corn 3 D Grains"†	Marathon	G 26. F 29.7	9. 11.	13. 9.5
5985	The Dewey Bros. Co., Blanchester, O. "Eagle 3 D Grains"†	Darien Center	G 30. F 29.3	10. 12.6	13. 9.1
5754	The Dewey Bros. Co., Blanchester, O. "Eagle 3 D Grains"†	Union	G 30. F 29.9	10. 14.1	13. 12.1
5471	The Dewey Bros. Co., Blanchester, O. "Eagle 3 D Grains"†	Buffalo	G 30. F 31.3	10. 13.63	13. 10.6
6112	Donahue-Stratton Co., Milwaukee, Wis. "Hiquality Spirits Distillers Grains"†	Sanitaria Spgs.	G 30. F 35.5	10. 9.	14. 8.7
5955	The Hottelet Co., Milwaukee, Wis. "Hector Dried Distillers Grains"†	Attica	G 30. F 29.4	10. 9.	14. 10.1

* These letters indicate, respectively, Guaranteed and Found.
† Found to be from corn, oats, rye and barley.
‡ Found to be from corn, oats, rye and barley, with light barley, light oats, barley screenings.

ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.
			Per ct.	*Per ct.*	*Per ct.*
	DISTILLERS' DRIED GRAINS (*concluded*):				
5766	Husted Milling Co., Buffalo, N. Y. "Husted Distillers Grains "†	Homer	G* 30. F* 31.8	8. 12.2	11. 9.9
5798	The Larrowe Milling Co., Detroit, Mich. "Staff Brand Dried Distillers Grains "‡	Preble	G 27. F 26.4	7. 9.7	9. 7.4
4942	Purdy Bros., Jamestown, N. Y. "Empire Corn Distillers Grains "§	Auburn	G 30. F 28.4	9. 10.41	12. 10.1
5517	Traders & Producers Supply Co., Buffalo, N. Y. "Chippewa Distillers Grains "¶	Sinclairville	G 30. F 25.4	10. 10.2	14. 7.9
6304	The Ubiko Milling Co., Cincinnati, O. "Goodrich Distillers Dried Grains."§	Genoa	G 27. F 28.5	8. 9.1	14. 10.6
4943	The Ubiko Milling Co., Cincinnati, O. "XXXX Fourex Grains " §	Auburn	G 31. F 32.9	12. 13.58	13. 10.7
	DRIED BREWERS' GRAINS:				
6428	Anheuser Busch Brewing Ass'n, St Louis, Mo. "Dried Brewers' Grains "	Middletown	G 21. F 26.8	6. 6.1	18. 13.5
5640	Atlantic Export Co. of Wis., Chicago, Ill. "Dried Brewers' Grains "	Albany	G 24. F 31.2	5. 6.8	17. 11.4
6315	Bartholomay Brewery Co., Rochester, N. Y. "Dried Brewers' Grains "	Rochester	G 18.40 F 23.9	6.11 7.5	24.76 13.3
6171	Bartholomay Brewery Co., Rochester, N. Y. "Dried Brewers' Grains "	Poughkeepsie	G 18.40 F 22.	6.11 6.7	24.76 14.3
6402	Chicago Grains & Feed Co., Chicago, Ill. "XXX Brewers' Dried Grains "	Washington-ville	G 25. F 31.4	5. 6.9	15. 11.3
5472	Farmers Feed Co., Buffalo, N. Y. "Dried Brewers' Grains Bull Brand "	Buffalo	G 27.20 F 27.7	6.30 7.56	17.20 12.6

* These letters indicate, respectively, Guaranteed and Found.
† Guaranteed, "Made from corn," found to be from corn, oats, rye and barley.
‡ Guaranteed, "Made principally from corn."
Found to be from corn, oats, rye and barley.
§ Found to be from corn, oats, rye and barley.
¶ Found to be from corn, barley, oats, and rye, with light barley and grain screenings.

ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.
			Per ct.	*Per ct.*	*Per ct.*
	DRIED BREWERS' GRAINS (*concluded*):				
6113	Hoffman & Co., Syracuse, N. Y. "Brewers' Dry Grains"	Sanitaria Springs	G* 23. F* 28.6	5.10 7.	15. 12.2
6192	The Hottelet Co., Milwaukee, Wis. "Holstein Dried Brewers' Grains"	Matteawan	G 25. F 25.	5. 6.1	14. 13. 5
6048	M. A. Joshel, Geneva, Ill. "Pure Dried Brewers' Grains"	Elmira	G 25. F 26.8	6. 6.6	—— 13.1
5630	Milwaukee Grains & Feed Co., Milwaukee, Wis. "Crown Brewers' Dried Grains"	Troy	G 25. F 29.1	5. 6.97	15. 12.1
5601	K. & E. Neumond, St. Louis, Mo. "Goldness Kalb Dried Brewers' Grains"	Guilderland Center	G 24. F 25.7	6. 6.3	13. 12.4
6132	The Penna. Central Brewing Co., Scranton, Pa. "Dried Brewers' Grains"	Conklin	G 23.71 F 26.5	7.14 6.6	15.85 12.
6119	Penn. Grain & Feed Co., Philadelphia, Pa. "Peerless Brewers' Dried Grains"	Candor	G 25. F 29.3	5. 6.3	15. 11.5
	GLUTEN FEEDS:				
5492	Clinton Sugar Refining Co., Clinton, Ia. "Clinton Gluten Feed"	East Aurora	G 20. F 25.1	3. 3.9	8. 7.
5634	Corn Products Refining Co., New York, N. Y. "Buffalo Gluten Feed"	Stephentown	G 23. F 26.	2. 2.8	8.5 5.9
5663	Corn Products Refining Co. New York, N. Y. "Crescent Gluten Feed"	Grand Gorge	G 23. F 24.	2. 4.7	8.5 5.7
5619	Corn Products Refining Co., New York, N. Y. "Globe Gluten Feed"	Schenectady	G 23. F 25.	2. 1.9	8.5 6.4
6128	The Dewey Bros. Co., Blanchester, O. "Buckeye Gluten Feed"	New Woodstock	G 20. F 19.8	5. 4.1	15. 12.2

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Samples of Feeding Stuffs (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.
			Per ct.	*Per ct.*	*Per ct.*
	Gluten Feeds (*concluded*):				
5520	The Dewey Bros. Co., Blanchester, O. " Buckeye Gluten Feed "	Salamanca	G* 20. F* 20.5	5. 4.2	15. 11.9
5965	Douglas & Co., Cedar Rapids, Ia. " Douglas Gluten Feed "	North Java	G 20. F 22.8	2. 3.1	8. 6.4
5996	J. C. Hubinger Bros. Co., Keokuk, Ia. " Hubinger Gluten Feed "	Elba	G —— F 20.8	—— 3.2	—— 6.7
5611	J. C. Hubinger Bros. Co., Keokuk, Ia. " KKK Gluten Feed "	Albany	G 23.50 F 22.6	2.40 3.1	7.50 7.1
6404	The Huron Milling Co., Harbor Beach, Mich. " Jenks' Gluten Feed "	Goshen	G 22. F 24.1	3. 3.5	8. 6.2
6174	The Keever Starch Co., So. Columbus, O. " Keever Gluten Feed "	Poughkeepsie	G 22. F 18.4	4.5 4.5	7. 6.8
6036	A. Nowak & Son, Buffalo, N. Y. " Gluten "	Corning	G —— F 26.7	—— 2.5	—— 6.2
5484	Piel Bros. Starch Co., Indianapolis, Ind. " P Bro Gluten Feed "	Buffalo	G 21. F 25.7	2. 2.43	8. 6.1
5751	A. E. Staley Mfg. Co., Decatur, Ill. " Staley's Gluten Feed "	Owego	G 23. F 23.6	2.50 2.6	12. 6.2
6460	Union Starch & Refining Co., Edinburg, Ind. " Union Gluten Feed "	Delanson	G 24. F 25.1	3. 3.3	6.30 6.8
	Gluten Meals:				
6046	Corn Products Refining Co., New York, N. Y. " Diamond Gluten Meal "	Horsehead	G —— F 42.8	—— 1.6	—— 2.6
5792	Corn Products Refining Co., New York, N. Y. " Diamond Gluten Meal "	Brewerton	G 40. F 44.5	1.5 3.2	4. 1.1

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	HOMINY FEED:					
6164	American Hominy Co., Indianapolis, Ind. "Homco Feed"	Hudson	G* 9.5 F* 11.1	7. 6.5	7. 4.6	A pure white corn product. Hominy feed.
6104	American Hominy Co., Indianapolis, Ind. "Homcoline Feed"	So. New Berlin	G 17. F 19.6	5. 7.7	7. 4.9	A pure white corn product. Corn germ meal.
5476	American Maize Products Co., New York, N. Y. "Cream of Corn Gluten Feed"	Williamsville	G 23. F 25.9	2.50 2.30	8.50 6.	Corn gluten feed.
5510	Ames-Burns Co., Jamestown, N. Y. "A. B. C. Fine White Hominy"	Collins	G 9. F 11.0	7. 7.4	5. 4.2	Hominy feed.
5790	E. I. Bailey, Cleveland, O. "Pearl Hominy Feed"	Manlius	G 9. F 11.2	7. 8.1	8. 4.8	Pure corn product. Hominy feed.
5770	M. F. Baringer, Philadelphia, Pa. "Hominy Feed"	Marathon	G 9. F 10.8	6. 7.9	10. 4.4	Hominy feed.
4938	Buffalo Cereal Co., Buffalo, N. Y. "Bufceco Hominy Feed"	Auburn	G 10. F 10.6	7. 6.4	4. 4.	Hominy feed.
6125	Donahue-Stratton Co., Milwaukee, Wis. "Hiquality Pure Hominy Feed"	Morrisville	G 10. F 11.2	7. 6.	7. 5.4	Hominy feed.

6140	East Waverly Milling Co., Waverly, N. Y. " Hominy Feed "	Waverly	G F	9. 10.8	6. 7.6	5. 3.2	Hominy feed.
6459	Elevator Milling Co., Springfield, Ill. " Ideal Hominy Feed Kiln Dried "	Worcester	G F	11.02 11.	7.70 8.3	—— 4.5	Hominy feed.
5668	J. & S. Emison & Co., Vincennes, Ind. " Baltic Hominy "	Delhi	G F	9.18 10.9	9.10 8.4	—— 3.8	Hominy feed.
5760	Empire Grain & Elevator Co., Binghamton, N. Y. " Pearl Hominy "	Preble	G F	10. 10.7	7. 7.30	6. 5.1	Hominy feed.
5787	Evans Milling Co., Indianapolis, Ind. " Evans Hominy Feed "	Oneida	G F	10. 10.5	7.5 8.2	7. 4.8	Hominy feed.
6006	U. S. Frumentum Co., Detroit, Mich. " Frumentum Hominy Feed "	Auburn	G F	9.50 11.3	7.30 8.4	7. 4.5	Hominy feed.
6110	Charles Herendeen Milling Co., Chicago, Ill. "Herendeen's Hominy Feed "	Chittenango	G F	10.15 11.	6.40 7.4	3.55 4.4	Made from choice white corn. Hominy feed.
6003	Husted Milling Co., Buffalo, N. Y. " Yellow Hominy Feed "	Auburn	G F	9. 10.3	6. 6.22	8. 3.7	Made from corn. Yellow hominy feed.
4944	Chas. A. Krause Milling Co., Milwaukee, Wis. " Badger Hominy Feed "	Auburn	G F	10. 11.2	6. 8.15	5. 4.4	Made from pure white corn. Hominy feed.
6423	Miner-Hillard Milling Co., Wilkes-Barre, Pa. " Choice Steam Cooked Hominy Feed "	Chester	G F	10. 11.	5. 6.2	5. 4.1	Hominy feed.

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number	Name and address of manufacturer or jobber and brand or trade name.	Where taken.		Crude protein.	Crude fat.	Crude fiber.	Ingredients.
				Per ct.	*Per ct.*	*Per ct.*	
	HOMINY FEED (*concluded*):						
5461	A. Nowak & Son, Buffalo, N. Y. "Justice Brand Hominy"	Bowmansville	G*	8.	6.	8.	
			F*	10.1	7.56	4.	Hominy feed.
4932	The Patent Cereals Co., Geneva, N. Y. "Hominy Feed"	Geneva	G	10.	7.	5.	Hominy.
			F	10.3	5.9	4.6	Hominy feed.
6185	The Quaker Oats Co., Chicago, Ill. "Yellow Hominy Feed"	Highland	G	9.	4.	4.	
			F	10.7	7.4	3.4	Yellow hominy feed.
5762	Suffern, Hunt & Co., Decatur, Ill. Acme Hominy Feed"	McGraw	G	9.30	7.10	10.	Compounded from white corn.
			F	10.2	7.9	4.7	Hominy feed.
5649	Tioga Mill & Elevator Co., Waverly, N. Y. "Economy Feed"	Watervliet	G	10.	5.	17.25	Hominy, brewers' grains, corn offal, cob meal, oat hulls, and oat middlings.
			F	10.2	4.7	14.4	As certified.
5655	(None given) "Yellow Corn Meal"	Port Jervis	G	—	—	—	
			F	10.6	7.4	3.5	Yellow hominy feed.
6303	(Not given) "Hominy"	Genoa	G	—	—	—	
			F	11.	8.4	3.5	Hominy feed.
	COMPOUNDED FEEDS:						
5548	Acme Milling Co., Olean, N. Y. "Acme Feed"	Olean	G	7.	3.	9.	Corn, hominy and oat hulls.
			F	9.7	3.9	5.	Corn, hominy feed, oat hulls.

6201	Acme Milling Co., Olean, N. Y. "Acme Feed"	Allegany	G	7.	3.	9.	Corn, hominy, oat hulls and one-half of 1 per cent salt.
			F	9.8	4.1	5.9	Ground corn, hominy feed, oat hulls, salt.
6074	J. & T. Adikes, Jamaica, N. Y. "Ground Feed"	Jamaica	G	8.75	3.	6.	Barley, corn and corn cob, oats and oat hulls.
			F	9.5	3.2	5.2	Barley, ground corn, oats, oat hulls, grain screenings consisting largely of ground weed seeds.
6075	J. & T. Adikes Jamaica, N. Y. "Nu Life"	Jamaica	G	8.	2.	10.	Oats, corn and corn bran, barley, alfalfa, sprouts and molasses.
			F	7.3	2.4	5.3	Oats, corn, corn bran, barley, alfalfa meal, screenings consisting largely of whole weed seeds, molasses.
6204	Akron Produce Co., Akron, N. Y. "Bower's Dairy Ration"	Akron	G	24.	6.	8.50	Made from gluten, distillers' grains, corn meal, oil meal, cottonseed meal, wheat bran, wheat middlings and salt.
			F	25.1	6.	6.9	Corn gluten feed, distillers' dried grains, corn meal, linseed meal, cottonseed meal, wheat bran, wheat middlings, salt.
5631	American Milling Co., Chicago, Ill. "Mixing Feed"	Stephentown	G	12.	2.50	12.	Ground and bolted grain screenings, molasses, clipped oat by-product, linseed meal, gluten feed and salt.
			F	12.3	5.6	11.8	Ground grain screenings, linseed meal, corn gluten feed, clipped oat by-product, molasses, salt.
5664	American Milling Co., Chicago, Ill. "Sucrene Alfalfa Horse & Mule Feed"	Grand Gorge	G	11.	2.50	12.	Corn, rolled oats, rolled barley, alfala, cottonseed meal, molasses and recleaned grain screenings, one-half of 1 per cent salt.
			F	13.6	3.4	11.4	As certified.

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ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	COMPOUNDED FEEDS (*continued*):					
5628	American Milling Co., Chicago, Ill. " Sucrene Dairy Feed "	Troy	G* 16.50	3.50	12.	Cottonseed meal, gluten feed, molasses, oat clippings and ground and bolted grain screenings, one-half of 1 per cent salt.
			F* 16.6	5.8	11.5	Cottonseed meal, corn gluten feed, oat clippings, ground grain screenings, molasses, salt.
6129	American Milling Co., Peoria, Ill. " Sucrene Horse & Mule Feed "	Syracuse	G 10.	2.50	12.	Recleaned grain screenings, molasses, cracked corn, linseed meal, rolled oats and salt.
			F 10.9	3.7	9.1	Grain screenings, cracked corn, rolled oats, molasses, salt.
5644	Atlantic Export Co., of Wis., Chicago, Ill. " White Cross Stock Feed "	Albany	G 10.	3.5	10.	Ground oats, ground barley, corn feed meal, wheat meal, ground corn bran, cottonseed meal, salt one-half of 1 per cent.
			F 10.	2.9	4.	As certified.
5954	The Attica Mills, Chesbro Bros., Attica, N. Y. " Mixed Feed 'E' "	Attica	G 23.	6.	10.	Distillers feed, oil meal, corn meal, cottonseed meal, gluten meal, bran, middlings.
			F 24.4	6.	8.6	Distillers' dried grains, linseed meal, corn meal, cottonseed meal, corn gluten meal, wheat bran, wheat middlings.
5958	The Attica Mills, Chesbro Bros., Attica, N. Y. " Molasses Screenings Feed "	Attica	G 10.	2.	10.	Grain screenings and molasses.
			F 12.9	6.8	8.2	As certified.

6305	J. G. Atwater & Son, Genoa, N. Y. "Corn & Oat Feed"	Genoa	G	—	—	—	Ground corn and oat feed.
			F	8.1	3.4	11.	Cracked corn, oats, oat shorts, oat hulls.
6336	C. F. Ault, Odessa, N. Y. "Corn, Oats & Bran"	Odessa	G	—	—	—	Corn, oats, toll grains (consisting of rye, barley, etc.) and bran.
			F	10.9	4.1	3.7	Ground corn, oats, rye, barley, buckwheat, wheat bran.
5711	The Beck Cereal Co., Detroit, Mich. "Royal Chop Feed"	Utica	G	8.31	5.10	5.81	Made from ground corn, oat middlings, oat shorts and oat hulls.
			F	9.2	5.3	4.6	Ground corn, oat middlings, oat shorts, oat hulls, salt.
6420	Belvidere Flouring Mill Co., Belvidere, N. J. "Mixed Feed"	Wisner	G	8.	2.40	20.	Corn, rye feed, oats, cob meal.
			F	9.7	2.9	7.6	Rye bran and middlings, small amount of ground corn, ground oats, ground corn cob.
5609	The Blatchford Calf Meal Factory, Waukegan, Ill. "Blatchford's Calf Meal"	Albany	G	24.	5.	6.	Locust bean meal, unpressed flaxseed, wheat flour, ground beans and peas, oil meal, cocoa shells, cocoanut meal, recleaned cottonseed meal, fenugreek, dried milk and salt.
			F	25.1	5.2	6.6	As certified.
5474	The Blatchford Calf Meal Factory, Waukegan, Ill. "Blatchford's Calf Meal"	Buffalo	G	24.	5.	6.	Locust bean meal, unpressed flaxseed, wheat flour, ground beans and peas, oil meal, cocoa shells, cocoanut meal, recleaned cottonseed meal, fenugreek, dried milk and salt.
			F	25.6	4.96	6.2	As certified.
6418	Blish Milling Co., Seymour, Ind. "Blish's Bulls Eye Mixed Feed"	Monroe	G	16.	4.40	9.10	Made of bran, middlings and ground wheat screenings.
			F	16.	4.7	6.2	Wheat bran, wheat middlings.
6059	S. W. Bowne Co., Brooklyn, N. Y. "Ground Feed"	Brooklyn	G	7.	3.	11.	Corn meal, hominy chops, oat hulls.
			F	8.9	3.8	3.9	As certified.

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ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	COMPOUNDED FEEDS (*continued*):					
6060	J. D. Braue, Inc., Jordan, N. Y. "Braue's Mixed Feed"	New York	G* 12.	4.	12.	Crushed oats, crushed corn and alfalfa meal.
			F* 12.4	3.7	10.6	As certified.
6061	J. D. Braue, Inc., Jordan, N. Y. "Braue's Mixed Feed with Molasses"	New York	G 12.	4.	12.	Corn, oats, alfalfa, and cane molasses.
			F 8.1	2.	6.6	Cracked corn, crushed oats, alfalfa meal, molasses.
6055	Brooklyn Elevator & Milling Co., Brooklyn, N. Y. "Bemco Stock Feed"	Brooklyn	G 9.	3.	8.	Corn, oats and oat hulls, barley and wheat bran.
			F 9.4	4.3	4.1	Corn meal, oats, barley, small amount of wheat bran, screenings.
5470	Buffalo Cereal Co., Buffalo, N. Y. "Bufceco Chop Feed"	Buffalo	G 7.	3.	9.	Corn, hominy feed, oat bran, oat hulls.
			F 8.6	4.67	9.2	As certified.
6455	Buffalo Cereal Co., Buffalo, N. Y. "Bufceco Creamery Feed"	Oneonta	G 18.	4.	8.	Corn, wheat middlings, hominy feed, cottonseed meal, gluten feed, oat hulls.
			F 19.8	5.5	8.1	Corn meal, wheat bran, wheat middlings, hominy feed, cottonseed meal, corn gluten feed, oat hulls.
6220	Buffalo Cereal Co., Buffalo, N. Y. "Bufceco Dairy Feed"	Buffalo	G 12.	3.	8.	Corn, wheat middlings, hominy feed, gluten feed, oat hulls.
			F 13.2	5.3	8.5	Ground corn, wheat bran, wheat middlings, hominy feed, corn gluten feed, oat hulls.

6151	Buffalo Cereal Co., Buffalo, N. Y. "Bufceco Horse Feed"	Watervliet	G	10.	4.	8.	Oats, corn, barley, gluten feed, wheat middlings, hominy feed, ground oats, oat hulls, oat bran, oat middlings.
			F	12.4	4.5	8.6	Crushed oats, cracked corn, barley, corn gluten feed, linseed meal, wheat middlings, hominy feed, oat middlings, oat shorts, oat hulls.
6182	Buffalo Cereal Co., Buffalo, N. Y. "Bufceco Stock Feed"	Poughkeepsie	G	8.	4.	9.	Corn, hominy feed, oat hulls, oat bran, gluten feed.
			F	10.3	5.3	9.2	Ground corn, hominy feed, oat bran, oat hulls.
5466	Buffalo Cereal Co., Buffalo, N. Y. "Iroquois Chop Feed"	Buffalo	G	7.	3.	9.	Ground corn, hominy feed, oat bran, oat hulls.
			F	11.1	4.93	9.	As certified.
6325	Cataract City Milling Co., Niagara Falls, N. Y. "Niagara Bran"	Hamlin	G	15.19	4.8	——	
			F	15.6	5.4	9.2	Wheat bran and screenings.
4929	Chapin & Co., Hammond, Ind. "Unicorn Dairy Feed"	Geneva	G	26.	5.5	10.	Corn distillers' grains, cottonseed meal, linseed meal, hominy meal, gluten feed, corn starch by-product with corn bran, brewers' grains, barley feed, malt sprouts and pure wheat bran.
			F	27.	7.43	9.4	Distillers' dried grains, cottonseed meal, corn gluten feed, brewers' dried grains, light barley, malt sprouts, hominy meal.
6045	Chase Hibbard Milling Co., Breesport, N. Y. "No. 2 Chop Feed"	Breesport	G	——	——	——	Toll grains and "corn bran and corn flour" resulting from manufacture of cracked corn and fine table meal.
			F	9.7	3.1	4.6	Corn feed meal, ground oats, rye, wheat, buckwheat.

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ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	COMPOUNDED FEEDS (*continued*):					
6020	Chesbro Milling Co., Salamanca, N. Y. "Chesbro's Stock Feed"	Weedsport	G* 9.	3.25	9.	Corn, barley, cottonseed meal, red dog flour, oat shorts, oat midds, oat hulls, one half of 1 per cent salt.
			F* 11.9	6.	9.1	Ground corn, small amount of barley, small amount cottonseed meal, red dog flour, oat shorts, oat middlings, oat hulls, salt.
5988	The Chesbro Milling Co., Salamanca, N. Y. "Peerless Dairy Feed"	Avon	G 23.	7.	9.	Brewers' grains, cottonseed meal, oil meal, bran, middlings, malt sprouts, hominy.
			F 17.9	7.	7.5	Distillers' dried grains, wheat bran, wheat middlings, malt sprouts, hominy feed, ground corn.
6021	The Chesbro Milling Co., Salamanca, N. Y. "Peerless Dairy Feed"	Weedsport	G 24.	7.	9.	Brewers' grains, cottonseed meal, oil meal, bran, middlings, malt sprouts, hominy.
			F 22.	7.9	8.7	Brewers' dried grains, distillers' dried grains, cottonseed meal, wheat bran, wheat middlings, malt sprouts, hominy feed, screenings consisting of weed seeds partly ground.
5977	Chesbro Milling Co., Salamanca, N. Y. "Trojan Feed"	Silver Springs	G 7.	3.	12.	Corn, barley, oat shorts, oat midds, oat hulls and one-half of 1 per cent salt.
			F 11.	4.9	8.4	Ground corn, small amount of barley, hominy feed, oat shorts, oat middlings, oat hulls, salt.

5641	Clover Leaf Milling Co., Buffalo, N. Y. " Clover Leaf Dairy Feed "	Albany	G	16.50	3.50	12.	Cottonseed meal, gluten feed, mixed broken grains consisting of wheat, corn, barley, flax, speltz, ground grain screenings, oat clips, molasses and a small percentage of salt.
			F	16.5	4.8	10.5	Cottonseed meal, corn gluten feed, oat clippings and ground grain screenings, containing weed seeds, molasses.
5507	Clover Leaf Milling Co., Buffalo, N. Y. " Clover Leaf Dairy Feed "	Jamestown	G	16.50	3.50	12.	Cottonseed meal, gluten feed, mixed broken grains containing corn, oats, barley, wheat, speltz, oat clips, molasses and a small percentage of salt.
			F	17.3	3.4	10.8	Cottonseed meal, corn gluten feed, clipped oat by-product and ground grain screenings, molasses, salt.
6317	Clover Leaf Milling Co., Buffalo, N. Y. " Peerless Dairy Ration "	Scottsville	G	21.	7.	9.	Gluten feed, distillers' grains, wheat bran, cottonseed meal, molasses and a small percentage of salt.
			F	21.4	5.6	9.4	Corn gluten feed, distillers' dried grains, wheat bran, cottonseed meal, ground grain screenings, molasses, salt.
6551	Commercial Milling Co., Detroit, Mich. " Dandy Feed "	Plattsburg	G	8.	5.	8.	Corn meal, wheat and oat midds, oats and oat hulls.
			F	8.9	4.1	6.3	Corn feed meal, oat hulls, small amount of oats, oat middlings and wheat middlings.
5712	Commercial Milling Co., Detroit, Mich. " Henkels Chop Feed "	Utica	G	8.	5.	8.	Corn meal, wheat and oat midds, oats and oat hulls.
			F	8.8	4.3	6.2	Corn bran, corn feed meal, wheat middlings, oats, oat middlings, oat hulls.
6421	Commonwealth Feed Mills Co., St. Louis, Mo. " Alfalfa and Molasses "	Wisner	G	10.	.7	20.	Alfalfa and molasses.
			F	10.1	1.3	21.1	As certified.

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ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	COMPOUNDED FEEDS (*continued*):					
6422	Commonwealth Feed Mills Co., St. Louis, Mo. "Missouri Sweet Horse and Mule Feed"	Wisner	G* 10.	2.40	17.	Alfalfa, corn, oats, molasses, ground peanuts and hulls, and one-third of 1 per cent salt.
			F* 10.2	3.4	14.6	As certified.
6407	W. H. Coonrod, Port Jervis, N. Y. "Horse Feed"	Port Jervis	G 8.	3.	14.	Ground corn, corn bran, ground oats, wheat and rye middlings, oatmeal mill by-products (oat hulls and oat middlings), Star Feed (hominy feed and ground corn cob), wheat flour, and one-half of 1 per cent salt.
			F 10.4	3.8	5.8	As certified.
6170	Corn Products Refining Co., New York, N. Y. "Queen Feed"	Poughkeepsie	G 20.	2.	8.5	Corn starch by-product with bran.
			F 22.3	4.5	6.5	Corn gluten feed.
6053	The Corno Mills Co., St. Louis, Mo. "Corno Horse and Mule Feed"	New York	G 10.	3.50	12.	Mixture of ground alfalfa, ground corn, cottonseed meal, hominy feed, oat hulls, oat middlings.
			F 10.9	3.7	11.8	Alfalfa meal, cracked corn, cottonseed meal, hominy feed, oat middlings, oat hulls.
5656	Crawford Bros., Walton, N. Y. "Crawford Stock Feed"	Hamden	G 9.	4.	12.	Ground corn, hominy feed, corn germ meal, oat hulls, wheat bran and wheat middlings.
			F 10.4	6.6	9.5	As certified.

5542	E. N. Cross, Randolph, N. Y. "Red Mill Perfection Dairy Feed"	Randolph	G	25.	7.	11.	Corn distillers' grains, hominy feed and corn meal, 41 per cent cottonseed meal, fancy winter bran, old process oil meal, fancy malt sprouts, gluten feed.
			F	23.6	6.8	9.1	Corn distillers' dried grains, hominy feed, corn meal, cottonseed meal, wheat bran, linseed meal, malt sprouts, corn gluten feed.
6090	Crow & Williams, Ossining, N. Y. "Crow & Williams Mixed Feed"	Ossining	G	8.	3.	12.	Corn, hominy, wheat bran, light oats, wheat middlings.
			F	10.1	3.8	5.3	As certified.
6026	J. G. Davis Co., Rochester, N. Y. "J. G. Davis Co.'s Choice Clean Bran"	Rochester	G	14.	3.	12.	
			F	15.9	5.7	8.9	Wheat bran and screenings.
5800	The Dewey Bros. Co., Blanchester, O. "Dewey's Ready Ration"	New Berlin	G	25.	7.	9.	
			F	25.4	7.6	9.4	Distillers' dried grains, wheat bran, malt sprouts, cottonseed meal, linseed meal, hominy feed, and salt.
5558	Duluth Superior Mfg. Co., Duluth, Minn. "Boston Mixed Feed"	Chatham	G	15.	4.	9.50	Made from wheat bran, middlings and low grade flour.
			F	16.2	5.4	7.9	As certified.
5989	Edward Dwyer, Hemlock, N. Y. "Oat & Rye Feed"	Hemlock	G	——	——	——	Oats and rye.
			F	12.4	3.7	5.	Ground oats, ground barley, ground wheat and ground rye.
6106	Empire Grain & Elevator Co., Binghamton, N. Y. "Never Fail Dairy Feed"	Chenango Forks	G	25.	6.	9.	Cottonseed meal, distillers' grains, linseed meal, gluten meal, brewers' grains, corn meal, barley malt sprouts, wheat bran, salt not to exceed three-quarters of 1 per cent.
			F	26.4	6.3	8.1	Cottonseed meal, distillers' dried grains, linseed meal, corn gluten meal, brewers' dried grains, kaffir corn meal, malt sprouts, wheat bran, salt.

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ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	COMPOUNDED FEEDS (*continued*):					
5529	The Empire Mfg. Co., Franklinville, N. Y. "Empire Stock Feed"	Franklinville	G *20.	3.	8.	Malt sprouts, wheat bran, corn, cottonseed meal, gluten, oil meal, distillers' grains.
			F* 24.	3.6	8.7	Malt sprouts, wheat bran, corn, cottonseed meal, corn gluten feed, linseed meal, distillers' dried grains.
5774	Empire Mills, Olean, N. Y. "Empire Feed"	McGrawville	G 7.50	3.	9.	Corn, hominy, oat hulls.
			F 8.7	4.	5.7	Ground corn, hominy feed, oat hulls.
6504	Empire Mill & Coal Co., Schaghticoke, N. Y. "Empire Milk Producer"	Schaghticoke	G 14.5	2.4	10.5	Corn meal, wheat bran, wheat middlings, rye middlings, cottonseed meal, cottonseed hulls, B meal, rye, oats and buckwheat screenings, mill sweepings, and malt sprouts, fine salt.
			F 17.5	3.3	11.6	Corn feed meal, wheat bran, wheat middlings, rye middlings, cottonseed meal, cottonseed hulls, ground rye, ground oats, malt sprouts, buckwheat screenings, consisting of buckwheat hulls and straw, salt.
6077	Erler Co., Riverhead, N. Y. "Erler's Cow Feed"	Riverhead	G 11.25	3.	7.10	Wheat bran, oil meal, 1 per cent salt and molasses.
			F 11.1	2.9	5.9	Wheat bran, small amounts of linseed meal and cottonseed meal, molasses, salt.
6435	Everett & Treadwell Co., Kingston, N. Y. "C. O. & W. Feed"	Kingston	G 11.	3.50	5.50	Ground corn, corn bran, ground oats, wheat middlings.
			F 12.8	3.7	5.1	As certified.

6091	The Evergreen Alfalfa Mill, Kearney, Neb. "Pure Alfalfa With Molasses"	Ossining	G	15.	2.50	27.50	
			F	8.3	.8	15.9	Alfalfa meal, molasses.
6111	Faramel Mfg. Co., Buffalo, N. Y. "Boggs Competition Horse Feed"	Syracuse	G	9.	3.	3.50	Rolled oats, cracked corn, wheat bran, and molasses.
			F	11.1	3.4	3.7	As certified.
6219	Faramel Mfg. Co., Buffalo, N. Y. "Faramel Dairy Feed"	Lewiston	G	22.06	3.77	8.92	Distillers' dried grains, gluten meal, oil meal, bran, barley by-product, molasses and one per cent of salt.
			F	21.9	3.9	7.7	Brewers' dried grains, corn gluten feed, linseed meal, wheat bran, malt sprouts, molasses, salt.
5972	Faramel Mfg. Co., Buffalo, N. Y. "Faramel Horse Feed"	Warsaw	G	10.44	4.25	6.25	Oats, corn, wheat bran, and molasses.
			F	9.8	3.9	5.1	Crushed oats, cracked corn, wheat bran, molasses.
6327	Faramel Mfg. Co., Buffalo, N. Y. "Dairy Feed"	Charlotte	G	22.	3.	9.	Brewers' dried grains, buffalo gluten feed, oil meal, wheat bran, barley by-products, molasses and 1 per cent of salt.
			F	18.	3.3	7.2	Brewers' dried grains, corn gluten feed, linseed meal, wheat bran, barley by-products consisting of light barley, screenings, small amount of malt sprouts, molasses, salt.
5506	Faramel Mfg. Co., Buffalo, N. Y. "Horse Feed"	Jamestown	G	9.	4.	6.	Oats, corn, wheat bran and molasses.
			F	9.81	4.	5.1	As certified.
6326	Faramel Mfg. Co., Buffalo, N. Y. "Horse Feed"	Charlotte	G	9.	4.	6.	Oats, corn, wheat bran and molasses.
			F	11.	3.6	4.8	Crushed oats, cracked corn, wheat bran, molasses.
5998	Federal Milling Co., Lockport, N. Y. "Lucky Spring Bran"	East Pembroke	G	15.	4.5	11.	
			F	15.9	5.8	9.1	Wheat bran and screenings.

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	COMPOUNDED FEEDS (*continued*):					
5991	Galbraith Milling Co., Mt. Morris, N. Y. "Chop Feed"	Mount Morris	G* ——	——	——	Corn, oats, and toll grains consisting of whatever toll grains are on hand.
			F* 10.8	4.1	5.5	Ground oats, ground rye, barley and a small amount of wheat.
5783	General Flour & Feed Co., Buffalo, N. Y. "Big 4 Feed"	Syracuse	G 7.	3.	12.	Cracked corn, corn and cob meal, ground oat hulls, oat middlings, corn bran.
			F 7.8	3.6	10.5	As certified.
5782	General Flour & Feed Co., Buffalo, N. Y. "Buffalo Meal"	Syracuse	G 7.	3.	7.	Corn and cob meal, the amount of cob used being the same as though ear corn was ground cob and all.
			F 8.7	3.9	3.6	As certified.
5781	General Flour & Feed Co., Buffalo, N. Y. "Honest Cow Feed"	Syracuse	G 24.	6.	9.	Distillers' dried grains, gluten, brewers' dried grains, wheat middlings, corn meal, wheat bran, 1 per cent salt, corn bran, cottonseed meal, linseed meal.
			F 24.4	8.	7.5	Distillers' dried grains, corn gluten feed, wheat bran, wheat middlings, corn meal, corn bran, cottonseed meal, linseed meal, salt, screenings consisting mostly of whole weed seeds.
5778	General Flour & Feed Co., Buffalo, N. Y. "Standard M & S"	Syracuse	G 10.	3.	10.	Wheat bran, B meal which is composed of corn and cob meal, the amount of cob used being the same as though ear corn was ground cob and all.
			F 11.6	4.6	6.1	As certified.

5791	Gilbert & Nichols Co., Fulton, N. Y. "Fulton Dairy Feed"	Brewerton	G	26.	6.	9.	Distillers' grains, malt sprouts, brewers' grains, cottonseed meal, old process oil meal, buckwheat middlings, gluten feed, wheat bran, corn meal and ground oats mixed with a very small quantity of salt.
			F	26.2	5.6	8.	Distillers' dried grains, malt sprouts, brewers' dried grains, cottonseed meal, linseed meal, buckwheat middlings and buckwheat hulls, corn gluten feed, wheat bran, corn meal, oats, salt.
6212	Globe Elevator Co., Buffalo, N. Y. "Buffalo Dairy Mixed Feed"	Buffalo	G	12.	5.	9.	Wheat bran, corn bran, wheat flour, wheat middlings, salt three-fourths of 1 per cent.
			F	13.4	6.5	7.	As certified.
6103	Globe Elevator Co., Buffalo, N. Y. "Buffalo Stock Feed"	New Berlin	G	9.	4.	9.	Corn, barley, oats, red dog flour, oat hulls, oat middlings, hominy feed, cottonseed meal, salt three-fourths of 1 per cent.
			F	10.3	3.3	6.9	Ground corn, oats, red dog flour, oat hulls, oat middlings, hominy feed, cottonseed meal, salt.
6213	Globe Elevator Co., Buffalo, N. Y. "Buffalo Stock Feed"	Buffalo	G	8.	4.	9.	Corn, oats, oat hulls, oat shorts, wheat flour, cottonseed meal, hominy and salt three-fourths of 1 per cent.
			F	11.5	4.3	6.	As certified.
6056	Globe Molasses Feed Co., Brooklyn, N. Y. "Globe Horse Feed"	Brooklyn	G	4.05	.25	13.25	Ground oats, whole grain screenings, cracked corn, alfalfa meal, cane molasses.
			F	5.6	1.	9.4	As certified.
6039	Globe Elevator Co., Buffalo, N. Y. "No. 1 Chop Feed"	Elmira	G	7.	3.	9.	Ground corn and oats, oat hulls, flour middlings, salt one-half of 1 per cent.
			F	7.9	3.4	7.6	As certified.

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ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	COMPOUNDED FEEDS (*continued*):					
5497	D. H. Grandin Milling Co., Jamestown, N. Y. "Grandin's Stock Food"	North Collins	G* 8.50	3.50	10.	Pure oats, corn, barley, barley middlings, hominy feed, oat hulls and salt.
			F* 11.5	6.2	7.5	As certified.
6410	The Great Western Cereal Co., Chicago, Ill. "Gregson's Calf Meal"	Monticello	G 25.	5.	5.	Maximum salt three quarters of one per cent. Made from oat meal, barley, linseed and cottonseed.
			F 25.	6.	4.4	Oat meal, barley middlings, linseed meal, cottonseed meal, fenugreek, salt.
6190	Howard H. Hanks Co., Chicago, Ill. "Kingfalfa Horse Feed"	Fishkill-on-Hudson	G 10.25	3.25	12.	Alfalfa, corn, oats, syrup.
			F 10.7	1.2	10.7	Alfalfa meal, cracked corn, oats, molasses.
6189	Howard H. Hanks Co., Chicago, Ill. "Meadow Feed"	Fishkill-on-Hudson	G 11.	15.	20.	Alfalfa meal, molasses.
			F 12.2	.7	14.7	As certified.
6437	The Hecker Cereal Co., New York, N. Y. "Hecker's Chop Feed"	Saugerties	G 7.50	3.	9.	Ground corn, ground oats, hominy feed, oat hulls, one-half of one per cent salt.
			F 9.2	5.1	8.9	As certified.
6187	The Hecker Cereal Co., New York, N. Y. "Hecker's Horse Feed"	Fishkill-on-Hudson	G 11.	4.	9.	Ground oats, hominy feed, ground corn, wheat middlings, red dog, oat hulls, linseed meal, salt one-half of one per cent, corn starch by-product with corn bran.
			F 12.9	5.	8.7	Hominy feed, ground corn, wheat middlings, red dog flour, linseed meal, corn gluten feed, crushed oats, oat hulls, salt.

6439	The Hecker Cereal Co., New York, N. Y. "Hecker's Stock Feed"	Catskill	G 10.	4.	9.	Ground corn, ground barley, red dog, oat middlings, oat shorts, oat hulls, hominy feed, cottonseed meal, salt one-half of one per cent.
			F 10.2	4.9	8.6	As certified.
6215	Henry & Missert, Buffalo, N. Y. "B. S. Stock Food"	Buffalo	G 13.	3.	10.50	Composed of flour, bran and middlings from wheat, malt sprouts, gluten feed, ground flax seed and ground wheat screenings.
			F 15.3	3.8	11.1	Wheat bran, wheat middlings, wheat flour, malt sprouts, cottonseed meal, distillers' dried grains, ground flax seed, ground corn, ground corn cob, ground grain screenings.
6214	Henry & Missert, Buffalo, N. Y. "Holstein Milk Food"	Buffalo	G 17.35	17.	9.50	Ground flax seed and flax screenings.
			F 16.3	14.4	12.1	Ground flax screenings, oat refuse containing flax seed and weed seeds, cottonseed meal, cottonseed hulls.
5487	Henry & Missert, Buffalo, N. Y. "Matchless Complete Ration Dairy Feed"	Buffalo	G 26.	7.	16.	Corn distillers' grains, cottonseed meal, ground barley, malt sprouts.
			F 25.7	6.8	10.	Distillers' dried grains, corn meal, cottonseed meal, malt sprouts, salt.
6604	The H-O Company, Buffalo, N. Y. "De-Fi Feed"	Poughkeepsie	G 8.	3.	21.	Oat hulls, oat bran, corn, hominy feed, wheat midds, oat midds, salt.
			F 10.2	3.	12.9	Oat hulls, oat shorts, oat middlings, cracked corn, hominy feed, wheat middlings, salt.
6155	The H-O Company, Buffalo, N. Y. "The H-O Co.'s Algrane Horse Feed"	Troy	G 11.	4.	9.	Oats, oat hulls, oat shorts, wheat midds, ground corn, hominy feed, salt one-half of 1 per cent, corn starch by-product with bran.
			F 13.1	3.8	7.7	Oats, oat shorts, oat hulls, wheat middlings, ground corn, hominy feed corn gluten feed, salt.

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ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	COMPOUNDED FEEDS (*continued*):					
6015	The H-O Company, Buffalo, N. Y. "The H-O Co.'s Algrane Milk Feed"	Canandaigua	G* 14.	4.	10.	Oat hulls, wheat midds, cottonseed meal, oat shorts, corn starch by-product with bran, ground corn, ground oats, one-half of 1 per cent salt.
			F* 17.7	8.2	8.9	Wheat middlings, cottonseed meal, corn gluten feed, ground corn, ground oats, oat shorts, oat hulls, salt.
6210	The H-O Company, Buffalo, N. Y. "The H-O Co.'s Horse Feed with Molasses"	Buffalo	G 11.	4.	10.	Oats, oat shorts, ground corn, oat hulls, wheat middlings, hominy feed, corn starch by-product with bran, salt one-half of 1 per cent, molasses.
			F 12.1	4.3	7.8	Oats, oat shorts, oat hulls, cracked corn, wheat middlings, hominy feed, corn gluten feed, small amount molasses, salt.
6206	The H-O Company, Buffalo, N. Y. "The H-O Co.'s Milk Feed with Molasses"	Buffalo	G 14.	4.	10.	Oat hulls, wheat midds, cottonseed meal, oat shorts, corn starch by-product with bran, ground corn, ground oats, salt one-half of 1 per cent, molasses.
			F 18.1	4.1	9.3	Oat hulls, oat shorts, wheat middlings, cottonseed meal, corn gluten feed, ground corn, oats, molasses, salt.
6167	The H-O Company, Buffalo, N. Y. "New England Stock Feed"	Hudson	G 9.	4.	9.	Wheat middlings, ground corn, hominy feed, oat hulls, oat shorts, ground oats, one-half of 1 per cent salt.
			F 10.7	5.5	8.4	As certified.

6037	Hodgman Milling Co., Painted Post, N. Y. "Chop Feed"	Painted Post	G	9.69	3.88	——	Corn, corn offal, oats, oat hulls, oat middlings, barley, oat skimmings.
			F	9.2	3.3	6.3	As certified.
5990	Walter H. Humphrey, Mount Morris, N. Y. "Chopped Feed"	Mount Morris	G	——	——	——	Corn, oats and wheat product.
			F	12.2	4.	5.7	Ground oats, corn meal, wheat bran, wheat middlings.
6168	Husted Milling Co., Buffalo, N. Y. "Husted O-Molene Horse Feed"	Hudson	G	9.	3.	7.	Ground oats, cracked corn, corn bran, wheat bran, molasses.
			F	11.7	4.7	6.3	As certified.
6017	Husted Milling Co., Buffalo, N. Y. "Monarch Chop Feed"	Canandaigua	G	7.50	3.50	9.	Corn meal, whole oats, ground oats, oat hulls, hominy feed, salt three-fourths of 1 per cent.
			F	10.	4.7	9.6	As certified.
4950	Husted Milling Co., Buffalo, N. Y. "Monarch Horse Feed with Molasses"	Auburn	G	7.	3.	9.	Corn meal, ground oats, whole oats, hominy feed, oat hulls, wheat middlings, molasses, salt three-fourths of 1 per cent.
			F	10.8	4.4	5.4	Corn, corn offal, oats, oat clippings containing oat hulls, molasses, salt.
5539	Hydraulic Milling Co., Buffalo, N. Y. "Hydraulic Milling Co.'s Standard Chop Feed"	Buffalo	G	6.44	2.53	6.	Corn meal, hominy, oat middlings, oat hulls, ground oats.
			F	9.5	4.5	6.4	As certified.
6101	Indiana Milling Co., Terre Haute, Ind. "Holstein Feed"	New Berlin	G	12.	3.	16.	Wheat bran, cob meal.
			F	10.2	3.5	17.3	As certified.
5763	Indiana Milling Co., Terre Haute, Ind. "Sterling Feed"	McGraw	G	9.80	2.75	16.	Wheat bran, ground corn, cob meal.
			F	9.7	3.60	15.6	As certified.

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ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	COMPOUNDED FEEDS (*continued*):					
6134	International Sugar Feed Co., Minneapolis, Minn. "Climax Feed"	Oxford	G*12.50	3.50	12.	Cottonseed meal, molasses, ground cleaned grain screenings, ground clipped oat by-product, salt.
			F*13.5	4.6	12.5	Cottonseed meal, clipped oat by-product and ground grain screenings containing weed seeds partly ground, molasses, salt.
5724	International Sugar Feed Co., Minneapolis, Minn. "Climax Feed"	Little Falls	G 12.50	3.50	12.	Cottonseed meal, molasses, ground cleaned grain screenings, ground clipped oat by-product, salt.
			F 14.5	5.8	12.5	As certified.
6014	International Stock Food Co., Minneapolis, Minn. "International Grofast Calf Meal"	Canandaigua	G 25.	5.	10.	Fenugreek, locust bean, linseed oil meal, dried brewers' grains, cottonseed meal, flax seed, gluten feed, malt sprouts, pea meal, distillers' dried grains, cleaned grain screenings, red dog flour.
			F 25.2	6.2	9.6	Fenugreek, locust bean meal, linseed meal, red dog flour, ground grain screenings, salt.
5725	International Sugar Feed Co., Minneapolis, Minn. "Dairy Feed"	Little Falls	G 18.	3.50	12.	Cottonseed meal, molasses, cleaned grain screenings, clipped oat by-product, salt.
			F 18.6	5.9	11.8	As certified.
6411	International Sugar Feed Co., Minneapolis, Minn. "International Special Dairy Feed"	New Hampton	G 15.	3.50	12.	Cottonseed meal, molasses, ground cleaned grain screenings, ground clipped oat by-product and salt.
			F 17.7	5.5	11.7	Cottonseed meal, clipped oat by-product, ground grain screenings, molasses, salt.

5772	International Sugar Feed Co., Minneapolis, Minn. "International Special Dairy Feed"	Killawog	G	15.	3.50	12.	Cottonseed meal, molasses, ground cleaned grain screenings, ground clipped oat by-product and salt.
			F	16.	6.1	12.3	Grain screenings containing weed seeds partly ground, clipped oat by-product, cottonseed meal, salt, molasses.
5769	International Sugar Feed Co., Minneapolis, Minn. "International Special Molasses Feed"	Marathon	G	12.50	3.50	12.	Cottonseed meal, molasses, cleaned grain screenings (ground), oat clips containing oat hulls (ground), salt.
			F	15.2	4.1	8.8	Cottonseed meal, grain screenings largely ground, oat clippings containing ground oat hulls, molasses.
6414	International Sugar Feed Co., Minneapolis, Minn. "International Special Molasses Feed"	Walden	G	14.	3.5	12.	Cottonseed meal, molasses, cleaned grain screenings (ground), oat clips containing oat hulls (ground), salt.
			F	14.8	4.9	10.5	As certified.
5495	Jamestown Electric Mills, Jamestown, N. Y. "Jem Feed"	North Collins	G	9.	3.	10.	Yellow or white corn meal, oats, oat middlings, ground oat hulls, one-half pound of fine salt per 100 pounds.
			F	10.2	3.7	7.2	Corn meal, oats, oat hulls, oat middlings.
5516	Jamestown Electric Mills, Jamestown, N. Y. "Purity Milk Maker"	Gerry	G	22.	7.	11.	Distillers' dried grains, wheat bran, wheat middlings, gluten feed, cottonseed meal, linseed meal, corn meal, malt sprouts and a small percentage of fine salt.
			F	25.4	8.6	9.2	Distillers' dried grains, wheat bran, wheat middlings, corn gluten feed, cottonseed meal, linseed meal, corn meal, malt sprouts, salt.
6066	Kornfalfa Feed Milling Co., Kansas City, Mo. "Kay Molasses Feed"	New York	G	8.	1.50	17.	Corn, oats, alfalfa and molasses.
			F	10.7	1.5	12.4	Cracked corn, crushed oats, alfalfa meal, molasses.

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	COMPOUNDED FEEDS (*continued*):					
5626	Chas. A. Krause Milling Co., Milwaukee, Wis. "Badger Dairy Feed"	Troy	G*16.	2.	15.	Cottonseed meal, corn, oil meal, malt sprouts, dried brewers' grains, alfalfa meal and molasses, one-half of 1 per cent salt.
			F*17.5	4.5	13.9	Cottonseed meal, malt sprouts, brewers' dried grains, alfalfa meal, screenings containing weed seeds partly ground, molasses, salt.
6403	Chas. A. Krause Milling Co., Milwaukee, Wis. "Badger Fancy Mixed Feed"	Washington-ville	G 12.50	4.	9.	Wheat bran and maizo red dog flour.
			F 13.6	6.8	5.1	Wheat bran, white corn flour.
6051	Chas. A. Krause Milling Co., Milwaukee, Wis. "Badger Horse Feed"	New York	G 11.	2.	12.	Corn, oats, alfalfa, molasses and salt.
			F 10.4	2.	9.3	Cracked corn, crushed oats, alfalfa meal, molasses, salt.
6417	Chas. A. Krause Milling Co., Milwaukee, Wis. "Badger Wheat Middlings & Maizo Red Dog Flour"	Monroe	G 12.	4.50	7.	Wheat middlings and maizo red dog flour.
			F 12.3	6.8	3.2	Wheat middlings and white corn flour.
6409	Labar & Lain, Port Jervis, N. Y. "Horse Feed"	Port Jervis	G 6.5	3.	12.	Ground corn, and oats, oat middlings, oat hulls and corn bran.
			F 8.7	3.8	7.3	As certified.

6188	The Larrowe Milling Co., Detroit, Mich. "Larro-Feed"	Fishkill-on-Hudson	G	19.	3.	14.	Cottonseed meal, gluten feed (corn starch by-product with corn bran) dried distillers' grains (mainly from corn), dried beet pulp, wheat bran, wheat middlings, three-fourths of 1 per cent salt.
			F	19.5	4.2	11.7	Cottonseed meal, corn gluten feed, distillers' dried grains (mainly from corn), dried beet pulp, wheat bran, wheat middlings, salt.
5511	Law & Wilber, Inc., Collins, N. Y. "Square Deal Dairy Ration"	Collins	G	25.	7.	11.	Corn distillers' grains, hominy and corn meal, Owl 41 per cent cottonseed meal, fancy winter wheat bran, old process oil meal, fancy malt sprouts, gluten.
			F	22.1	6.3	7.6	Distillers' dried grains, hominy feed, corn meal, cottonseed meal, wheat bran, linseed meal, malt sprouts, corn gluten feed.
6434	Matthews & Harrison, Kingston, N. Y. "Arcade Stock Feed"	Kingston	G	7.50	3.25	13.	Ground corn, ground oats, oat hulls, hominy, wheat middlings, corn starch by-product and salt.
			F	8.9	3.6	11.9	Ground corn, ground oats, oat hulls, hominy feed, wheat middlings, small amount of corn gluten feed, salt.
6433	Matthews & Harrison, Kingston, N. Y. "Ulster Mixed Feed"	Kingston	G	7.	3.50	14.50	Ground corn, ground oats, oat hulls, wheat middlings, hominy, oat screenings, barley screenings and salt.
			F	8.8	3.5	13.6	Ground corn, corn bran, oats, oat hulls, wheat middlings, hominy feed, small amount of grain screenings, salt.
5632	R. H. McEwen Milling Co., Ogdensburg, N. Y. "Pontiac Dairy Feed"	Stephentown	G	24.	7.	10.	Distillers' dried grains, malt sprouts, hominy meal, cottonseed meal, linseed meal, wheat bran, one-half of 1 per cent salt.
			F	24.6	6.6	8.8	As certified.

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ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	COMPOUNDED FEEDS (*continued*):					
5765	Merchants' Distilling Co., Terre Haute, Ind. "Merchants High Grade Dairy Feed"	Little York	G*30.	11.	14.	
			F*31.1	11.7	10.7	Distillers' dried grains from corn, oats, rye and barley.
5999	Eugene H. Miller & Son, East Pembroke, N. Y. "Corn and Oat Chop"	East Pembroke	G ——	——	——	Corn, oats and wheat screenings.
			F 10.4	3.6	4.2	Ground corn and oats, wheat screenings.
6328	Moseley & Motley Milling Co., Rochester, N. Y. "Choice Wheat Bran"	East Rochester	G ——	——	——	
			F 17.5	6.4	7.5	Wheat bran and screenings.
6127	The Molassine Co., Boston, Mass. "Molassine Sphagnum Meal"	Earlville	G 7.	.50	7.	
			F 7.5	.70	5.6	Sphagnum moss, molasses.
6049	John C. Murphy, Elmira, N. Y. "No. 2 Chop Feed"	Elmira	G ——	——	——	Corn, oats, rye and toll grains.
			F 10.8	3.8	4.5	Ground corn, oats, rye, wheat, buckwheat.
6331	Mystic Milling & Feed Co., Rochester, N. Y. "Mystic Feed for Horses, Cattle and Swine"	Rochester	G 8.	3.	11.	Oats, oat hulls, oat middlings, corn meal, corn bran, rye middlings, cottonseed meal.
			F 9.8	4.2	11.2	As certified.
6052	National Oats Co., St. Louis, Mo. "Sweet Molasco Feed"	New York	G 10.	3.25	12.	Mixture of ground corn, ground alfalfa, cottonseed meal, oat hulls, oat middlings and molasses.
			F 8.7	2.2	12.5	As certified.

5504	Nichols Bros., Inc., Kennedy, N. Y. "Old Nick Milk Maker"	Kennedy	G	24.	5.25	11.	Distillers' grains, hominy and corn meal, cottonseed meal, oil meal, wheat bran, malt sprouts, gluten feed (which is corn starch by-product with corn bran).
			F	24.7	6.	7.6	Distillers' dried grains, hominy feed corn meal, cottonseed meal, linseed meal, wheat bran, malt sprouts, corn gluten feed.
6429	North-West Mills Co., Winona, Minn. "Sugarota Dairy Feed"	Middletown	G	16.50	3.50	12.	Cottonseed meal, malt sprouts, mixed broken grains from screenings containing corn, oats, barley, wheat, flax, speltz and buckwheat, molasses and salt.
			F	16.3	4.1	8.9	Cottonseed meal, malt sprouts, ground grain screenings, molasses, salt.
5797	North-West Mills Co., Winona, Minn. "Sugarota Dairy Feed"	Blodgett Mills	G	16.50	3.50	14.	Cottonseed meal, malt sprouts, mixed broken grains from screenings containing corn, oats, barley, wheat, flax, sprouts, and buckwheat, molasses and salt.
			F	17.4	5.	11.1	Cottonseed meal, malt sprouts, grain screenings partly ground, molasses.
4940	North-West Mills Co., Winona, Minn. "Sugarota Dairy Feed"	Auburn	G	16.50	3.50	14.	Made of cottonseed meal, malt sprouts, mixed broken grains from screenings containing corn, oats, barley, wheat, flax, speltz and buckwheat, molasses, and salt.
			F	17.6	6.9	10.2	Cottonseed meal, malt sprouts, ground grain screenings, molasses.
6163	A. Nowak & Son, Buffalo, N. Y. "Buffalo Horse Feed"	Hudson	G	7.	3.	12.	Ground oats, ground corn, hominy, oat hulls and wheat middlings.
			F	9.2	4.	9.5	Ground corn, oats, hominy feed, wheat middlings, oat hulls, screenings consisting largely of weed seeds.

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	COMPOUNDED FEEDS (*continued*):					
6225	A. Nowak & Son, Buffalo, N. Y. "Justice Brand Molassified Dairy Feed"	Buffalo	G*18.	4.	9.	Cottonseed meal, gluten feed, corn starch by-product with corn bran, linseed oil meal, ground corn, malt sprouts, distillers' dried grains, brewers' dried grains, wheat middlings, oat clippings, molasses and three-fourths of 1 per cent salt.
			F*20.9	4.9	7.2	Cottonseed meal, corn gluten feed, linseed meal, small amount of ground corn, malt sprouts, distillers' dried grains, brewers' dried grains, wheat middlings, oat clippings, grain screenings, molasses, salt.
5994	A. Nowak & Son, Buffalo, N. Y.		G 8.	2.	9.	Crushed oats, cracked corn, corn meal, wheat bran and molasses.
	"Justice Molassified Horse Feed"	Batavia	F 11.2	5.1	5.8	Crushed oats, cracked corn, wheat bran, molasses.
6035	A. Nowak & Son, Buffalo, N. Y. "Justice Brand Stock Feed"	Corning	G 10.	3.	9.	Ground corn, ground oats, oil meal, wheat middlings, oat meal mill by-product, oat middlings, oat hulls, oat shorts, and one-half of 1 per cent salt.
			F 10.5	5.	8.9	Ground corn, ground oats, oat middlings, oat shorts, oat hulls, flaked grits from corn.
6042	A. Nowak & Son, Buffalo, N. Y. "Union Horse Feed Molassified"	Van Etten	G 7.	3.	12.	Composed of ground corn, ground oats, oat clippings, hominy, oat hulls and molasses.
			F 9.	3.5	7.1	Ground corn, oats, oat hulls, screenings, molasses.

6224	A. Nowak & Son, Buffalo, N. Y. "Union Molassified Horse Feed"	Buffalo	G	7.	3.	12.	Ground corn, ground oats, oat clippings, oat hulls and molasses.
			F	8.4	3.4	6.6	Ground corn, oat hulls, oat clippings, grain screenings consisting largely of whole weed seeds, small amount of ground oats, molasses.
6556	Ogdensburg Roller Mills, Ogdensburg, N. Y. "Oswegatchie Feed"	Ft. Covington	G	6.60	3.18	9.	Corn meal, crushed oats, oat hulls and corncob meal.
			F	7.9	3.2	7.7	Corn meal, oat hulls, ground corncob, small amount of whole oats.
5549	Olean Mills, Olean, N. Y. "Chop Feed"	Olean	G	7.	2.	8.	Corn, hominy, barley, oats, oat hulls, oat middlings, ground together.
			F	10.1	4.2	3.9	Corn, hominy feed, oats, oat middlings, oat hulls.
5524	Omaha Alfalfa Milling Co., Omaha, Neb. "Green Meadow Dairy Feed"	Buffalo	G	11.	1.	25.	Alfalfa meal and syrup.
			F	12.1	.8	17.3	Alfalfa meal, molasses.
5525	Omaha Alfalfa Milling Co., Omaha, Neb. "Perfection Horse Feed"	Buffalo	G	10.	2.	12.	Corn, oats, alfalfa meal and molasses.
			F	11.	2.2	9.4	As certified.
5785	Oneida Milling Corporation, Oneida, N. Y. "Oneida Chief Milk Maker"	Oneida	G	24.	5.	10.	Oneida chief corn meal, Oneida chief wheat middlings, Oneida chief bran, Oneida chief ground oats, corn distillers' grains, cottonseed meal, fancy malt sprouts, gluten meal, old process oil meal.
			F	22.5	5.3	7.4	Corn meal, wheat bran, wheat middlings, ground oats, corn distillers' dried grains, cottonseed meal, malt sprouts, corn gluten meal, linseed meal.

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ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	COMPOUNDED FEEDS (*continued*):					
6198	Wm. Orr & Sons, Orr's Mills, N. Y. "Orr's Mixed Feed"	Orr's Mills	G* 7.	2.	15.	Whole corn, corn feed meal, corn bran, whole oats, rye middlings, wheat middlings, salt, clipped oat by-product.
			F* 11.3	4.1	5.2	Corn feed meal, corn bran, ground oats, rye middlings, wheat middlings, salt.
6065	Wm. H. Payne & Son, New York, N. Y. "Payne's Ground Feed"	New York	G 9.32	5.10	7.97	Whole oats, cracked corn, corn meal, oat hulls.
			F 10.5	4.2	7.4	Whole oats, crushed oats, cracked corn, corn meal, oat hulls and small amounts of kaffir corn, wheat and barley.
5468	M. C. Peters Mill Co., Omaha, Neb. "June Pasture"	Buffalo	G 10.	.5	26.	Alfalfa meal, light with molasses.
			F 12.4	1.0	15.2	Alfalfa meal, molasses.
5602	M. C. Peters Mill Co., Omaha, Neb. "Peters' Arab Horse Feed"	Albany	G 9.	2.	15.	Corn, oats, alfalfa and molasses.
			F 9.8	2.3	7.2	As certified.
5469	M. C. Peters Mill Co., Omaha, Neb. "Peters' King Corn, Oats, Alfalfa and Molasses Feed"	Buffalo	G 9.	1.5	18.	
			F 11.4	1.6	10.7	As certified.
5535	Phelps & Sibley Co., Cuba, N. Y. "White P & S Feed"	Cuba	G 7.	4.	8.	White corn, white hominy, oat hulls.
			F 8.4	4.1	8.	White corn, hominy feed, oat hulls.

5536	Phelps & Sibley Co., Cuba, N. Y. "Yellow P & S Feed"	Cuba	G	7.	3.	9.	Corn meal, corn feed meal and oat hulls.
			F	8.5	3.8	6.1	As certified.
5477	Postum Cereal Co., Ltd., Battle Creek, Mich. "CXX Feed"	Snyder	G	15.	2.	24.	Wheat, bran and molasses.
			F	17.6	4.4	13.8	Scorched and charred wheat bran.
6222	Purity Oats Co., Keokuk, Ia. "Purity Reground Oat hulls"	Buffalo	G	6.73	2.71	32.65	
			F	6.6	2.9	22.9	Oat hulls, oat shorts, oat middlings.
5646	The Quaker Oats Co., Chicago, Ill. "Blue Ribbon Dairy Feed"	Valatie	G	25.	4.	9.	Wheat bran, cottonseed meal, malt sprouts, molasses, hominy feed, clipped oats by-product.
			F	24.	4.5	9.8	Wheat bran, cottonseed meal, malt sprouts, hominy feed, oat hulls, molasses.
5607	The Quaker Oats Co., Chicago, Ill. "Boss Feed"	Albany	G	8.	3.	12.	Ground corn, hominy feed, oat meal mill by-product (oat hulls, oat middlings, oat shorts) and one-half of 1 per cent salt.
			F	9.4	4.6	7.5	As certified.
6008	The Quaker Oats Co., Chicago, Ill. "Buckeye Feed"	Moravia	G	15.50	4.50	8.50	Wheat mixed feed and rye shorts.
			F	16.6	5.1	7.6	Wheat bran, wheat middlings, rye middlings, screenings.
5771	The Quaker Oats Co., Chicago, Ill. "Daisy Dairy Feed"	Killawog	G	16.	4.	16.	Molasses, cottonseed meal, grain screenings meal, flax bran, oat meal mill by-product, (oat middlings, oat hulls, oat shorts).
			F	15.9	4.5	9.6	Grain screenings containing weed seeds partly ground, flax plant by-product, cottonseed meal, oat middlings, oat shorts, oat hulls, molasses.

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ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	COMPOUNDED FEEDS (*continued*):					
5647	The Quaker Oats Co., Chicago, Ill. " Daisy Dairy Feed "	Valatie	G* 16.	4.	16.	Molasses, cottonseed meal, malt sprouts, ground grain screenings meal, and clipped oat by-product.
			F* 16.2	4.9	10.1	Ground grain screenings containing weed seeds partly ground, cottonseed meal, malt sprouts, clipped oat by-product, molasses.
6172	The Quaker Oats Co., Chicago, Ill. " Green Cross Horse Feed "	Poughkeepsie	G 10.	3.	10.50	Alfalfa meal, ground corn, whole oats, molasses, oat meal mill by-product (oat middlings, oat hulls, oat shorts), and cottonseed meal.
			F 10.9	2.7	10.3	As certified.
5752	The Quaker Oats Co., Chicago, Ill. " Schumacher Calf Meal "	Owego	G 19.	8.	3.	Oat meal, wheat meal, ground flaxseed, dried casein with not to exceed one-half of 1 per cent bi-carbonate of soda.
			F 18.8	7.5	2.2	As certified.
5618	The Quaker Oats Co., Chicago, Ill. " Schumacher Stock Feed "	Schenectady	G 10.	3.25	10.	Ground corn, ground barley, hominy feed, wheat flour, wheat middlings, ground puffed rice, ground puffed wheat, oat meal by-products (oat middlings, oat hulls, oat shorts) cottonseed meal, one-half of 1 per cent salt.
			F 10.8	4.1	9.1	As certified.

5615	The Quaker Oats Co., Chicago, Ill. "Sterling Feed"	Albany	G	10.	3.50	10.	Hominy feed, ground corn, ground barley, wheat flour, wheat middlings, ground puffed wheat, ground puffed rice, oat meal mill by-product (oat middlings, oat hulls, oat shorts) cottonseed meal, and one-half of 1 per cent salt.
			F	12.	4.70	8.7	As certified.
6165	The Quaker Oats Co., Chicago, Ill. "Victor Feed"	Hudson	G	8.	3.	12.	Ground corn, hominy feed, oat meal mill by-product (oat middlings, oat hulls, oat shorts), and one-half of one per cent salt.
			F	9.2	5.4	10.8	As certified.
4934	The Quaker Oats Co., Chicago, Ill. "White Diamond Feed 'Coarse'"	Auburn	G	8.	3.25	9.	Ground corn, hominy feed, oat meal mill by-products, oat middlings, oat hulls, oat shorts, one-half of one per cent salt.
			F	8.5	4.45	6.	As certified.
6179	Ralston Purina Co., St. Louis, Mo. "Purina Feed with Molasses"	Poughkeepsie	G	9.	1.5	12.	Cracked corn, whole oats, ground alfalfa and molasses.
			F	10.8	3.	10.	As certified.
6062	Robinson-Danforth Co., St. Louis, Mo. "Winner Feed with Molasses"	Brooklyn	G	9.	1.5	12.5	Cracked corn, whole oats, ground alfalfa and molasses.
			F	9.9	2.4	9.5	As certified.
6078	Robinson & Erler, Inc., Riverhead, N. Y. "Erler's Excelsior Feed with Alfalfa"	Riverhead	G	9.	3.60	11.97	Corn, oats, oat feed, wheat bran, alfalfa, oil meal, molasses and salt.
			F	8.8	2.6	12.	Cracked corn, oats, oat middlings, oat shorts, oat hulls, wheat bran, alfalfa meal, small amount of linseed meal, molasses, salt.
6076	Robinson & Erler, Inc., Riverhead, N. Y. "Erler's Horse Feed"	Riverhead	G	10.08	3.	3.63	Corn meal, wheat bran, oil meal, one per cent salt, molasses.
			F	10.5	2.9	3.8	Corn meal, wheat bran, small amount linseed meal, molasses, salt.

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ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	COMPOUNDED FEEDS (*continued*):					
5622	Andrew Ruff's Sons, Troy, N. Y. "Ground Feed"	Troy	G* 13.25	4.50	6.	Corn meal, ground oats, wheat bran.
			F* 11.7	4.3	6.8	As certified.
6071	Shaw & Truesdell Co., Brooklyn, N. Y. "Santico"	Brooklyn	G 10.54	1.51	4.45	Ground barley, crushed oats, wheat middlings, wheat bran, corn meal, salt.
			F 10.4	3.2	3.4	As certified.
5660	Sheffield-King Milling Co., Minneapolis, Minn. "Gold Mine Feed"	Hobart	G 15.90	4.90	8.80	Bran, shorts, low grade flour, pulverized screenings, wheat product.
			F 17.	5.3	7.6	As certified.
6552	Southern Fibre Co., Portsmouth, Va. "Ko-Bos" Dairy Feed	Plattsburg	G 16.	3.10	32.	Cottonseed meal and cottonseed hulls.
			F 15.1	3.	25.8	As certified.
5624	Southern Fibre Co., Portsmouth, Va. "Royal Feed"	Troy	G 22.	4.	22.	Cottonseed meal and cottonseed hulls.
			F 19.	4.	22.8	As certified.
5557	The Sugarine Co., Chicago, Ill. "Sugarine Dairy Feed"	Chatham	G 16.50	3.50	12.	Cottonseed meal, gluten feed, molasses, oat clippings and ground and bolted grain screenings, one-half of 1 per cent salt.
			F 17.6	6.	10.6	Cottonseed meal, corn gluten feed, oat clippings and ground and bolted grain screenings, salt, molasses.

6408	The Sugarine Company, Chicago, Ill. "Sugarine Dairy Feed"	Port Jervis	G	16.50	3.50	12.	Molasses, cottonseed meal, gluten feed, ground and bolted grain screenings, clipped oat by-product, linseed meal and salt.
			F	16.5	5.5	12.1	Clipped oat by-product, ground grain screenings, cottonseed meal, linseed meal, molasses, salt.
6195	The Sugarine Co., Chicago, Ill. "Mixing Feed"	West Newburgh.	G	12.	2.50	12.	Ground and bolted grain screenings, molasses, clipped oat by-product, linseed meal, gluten feed and salt.
			F	14.3	5.1	11.6	Ground and bolted grain screenings, clipped oat by-product, corn gluten feed, cottonseed meal, molasses, salt.
5784	Syracuse Milling Co., Syracuse, N. Y. "Syragold Dairy Feed"	Onondaga Valley	G	19.	5.	7.	Yellow corn meal, wheat bran, cottonseed meal, old process oil meal.
			F	17.3	5.6	6.5	As certified.
6432	Thompson & Mould, Goshen, N. Y. "Matchless Corn Bran"	Pine Bush	G	10.7	7.8	8.	Hominy feed, corn bran.
			F	10.5	8.8	6.4	
5795	Tioga Mill & Elevator Co., Waverly, N. Y. "Derby Stock Feed"	Ithaca	G	10.50	4.90	9.	Corn offal, hominy, gluten, oat middlings, oat hulls.
			F	12.3	5.6	9.2	Cracked corn, hominy feed, corn gluten meal, oat middlings, oat hulls, kaffir corn, buckwheat, barley.
6139	Toledo Elevator, Branch, American Hominy Co., Indianapolis, Ind. "Star Feed"	Binghamton	G	7.	5.50	12.50	Hominy feed and ground corncob containing one-half of 1 per cent salt.
			F	8.	5.7	10.9	As certified.
5979	Geo. Tomlinson & Son, Perry, N. Y. "Chop Feed"	Perry	G	11.31	4.51	4.59	Corn, oats and bran.
			F	12.4	4.4	5.6	Ground corn and oats, and wheat bran.

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	COMPOUNDED FEEDS (*continued*):					
6022	The Ubiko Milling Co., Cincinnati, O. "Ubiko Horse and Stock Feed"	Macedon	G*16.	6.	9.	Old process linseed meal, hominy meal, wheat middlings, wheat bran, brewers' dried grains.
			F*20.3	6.6	8.	As certified.
5612	The Ubiko Milling Co., Cincinnati, O. "Union Grains Ubiko Biles Ready Dairy Ration"	Albany	G 24.	7.	9.	Fourex distillers' dried grains, choice cottonseed meal, old process linseed meal, white wheat middlings, winter wheat bran, hominy meal, barley malt sprouts, one-half of 1 per cent of fine table salt.
			F 24.1	7.3	8.5	As certified.
6166	United States Sugar Feed Co., Milwaukee, Wis. "U. S. Sugared Feed"	Hudson	G 15.	3.	12.	Cottonseed meal, gluten feed, mixed broken grains taken from wheat screenings, containing oats, barley, wheat, speltz, oat clips, molasses and a small percentage of salt.
			F 15.3	4.2	10.6	Cottonseed meal, ground grain screenings, oat clippings, molasses, salt.
5658	Van Buren & Conkling, Hobart, N. Y. "Horse Feed No. 2"	Hobart	G 11.	4.	5.	Corn, oats, barley and wheat feed.
			F 12.3	4.3	5.2	Ground wheat, wheat bran, wheat middlings, corn meal, ground oats, ground barley.
6427	L. R. Wallace, Middletown, N. Y. "Our Best Horse Feed"	Middletown	G 10.	3.	12.	Corn meal, ground oats, wheat middlings and wheat bran.
			F 10.4	3.6	3.8	Ground corn, oats and rye, wheat middlings.

6130	A. Waller & Co., Henderson, Ky. " Oneida Feed "	Syracuse	G	10.	2.5	17.	Winter wheat bran, winter wheat middlings, ground corn and cob.
			F	9.9	2.8	15.8	As certified.
6047	Washburn Mills, Minneapolis, Minn. " Washburn Crosby Co.'s Pure Hard Wheat Coarse Bran "	Horsehead	G	14.50	4.	11.	
			F	15.3	5.2	10.4	Wheat bran and screenings.
6309	Washburn Mills, Minneapolis, Minn. " Washburn Crosby Co.'s Pure Hard Wheat Coarse Bran	Levanna	G	14.50	4.	11.	
			F	15.3	5.8	9.6	Wheat bran and screenings.
6324	Washburn Mills, Minneapolis, Minn. " Washburn Crosby Co.'s Wheat Bran with Ground Screenings not Exceeding Mill Run "	Batavia	G	14.50	4.	11.	Wheat bran and screenings.
			F	14.9	5.6	9.5	As certified.
6401	Frank C. Wessells, Mountainville, N. Y. " Feed "	Mountainville	G	6.	2.	6.	Oats and corn ground with wheat middlings with about one per cent salt.
			F	11.6	4.2	4.3	As certified.
5981	W. J. Wheelock Co., Greigsville, N. Y. " Wheelock's Dairy Feed "	Wyoming	G	18.	4.	10.	Cottonseed meal, gluten, distillers' grains, wheat bran, clipped oat by-product, three-fourths of one per cent salt and molasses.
			F	18.3	5.4	9.6	Cottonseed meal, corn gluten meal, distillers' dried grains, wheat bran, clipped oat by-product and screenings, molasses, salt.

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	COMPOUNDED FEEDS (*concluded*):					
6197	The Western Grain Products Co., Hammond, Ind. "Hammond Dairy Feed"	Newburgh	G* 16.5	3.5	11.	Cottonseed meal, distillers' grains, malt sprouts, ground clipped oat by-product, ground corn, oats and barley, ground wheat screenings and molasses, three-tenths of one per cent salt.
			F* 16.	4.7	10.2	Cottonseed meal, distillers' dried grains, malt sprouts, clipped oat by-product, ground grain screenings containing ground weed seeds, molasses, salt.
	ANIMAL POULTRY FOODS.					
5642	Albany Rendering Co., Albany, N. Y. "Albany Bone & Meat Meal for Poultry"	Albany	G 35.	8.	——	
			F 41.8	15.08	——	Meat and bone meal.
6307	Armour Fertilizer Works, Chicago, Ill. "Armour's Meat Meal"	Union Springs	G 60.	7.	2.	Meat residue.
			F 59.7	8.6	——	Meat and blood meal.
6453	Baugh & Sons Co., Philadelphia, Pa. "Baugh's Meat Meal for Poultry"	Cooperstown	G 50.	14.	1.	Made of ground pure beef cracklings.
			F 52.8	15.3	——	Beef cracklings. Contains considerable bone.
5645	Baugh & Sons Co., Philadelphia, Pa. "Baugh's Special Ground Bone for Poultry"	Valatie	G 27.	3.	1.	Made of ground pure dry slaughter-house bones.
			F 26.9	1.3	——	Cracked bone.
6083	The Berg Co., Philadelphia, Pa. "3 Medal Poultry Meat"	Mineola	G 50.	13.	3.	
			F 43.9	12.7	——	Meat and bone scrap.

6173	Bowker Fertilizer Co., New York, N. Y. "Bowker's Animal Meal for Fowls & Chicks"	Poughkeepsie	G 40. F 44.8	5. 7.4	15. ——	Meat and bone scrap.
4941	H. F. Brehm, Waterloo Soap Works, Waterloo, N. Y. "Brehm's Beef Scrap & Bone"	Auburn	G 40. F 38.8	15. 22.19	—— ——	Sweet, clean beef cracklings with sound bone. As certified.
6087	The Brown Co., Trenton, N. J. "Pure Beef Scrap"	Lynbrook	G 50. F 43.5	15. 17.0	3. ——	Meat and bone scrap.
5463	Cyphers Incubator Co., Buffalo, N. Y. "High Protein Meat Scraps for Poultry"	Buffalo	G 45. F 41.	10. 10.4	—— ——	Meat and bone scrap.
6082	Darling & Co., Chicago, Ill. "Darling's Blood Meal for Poultry"	Long Island City	G 80. F 84.9	.50 .2	—— ——	Blood meal.
5509	Darling & Co., Chicago, Ill. "Darling's High Protein Meat Scraps for Poultry"	Collins	G 55. F 55.5	.5 8.7	3. ——	Meat and bone scrap.
5537	Jacob Dold Packing Co., Buffalo, N. Y. "Dold Quality Digester Tankage"	Buffalo	G 60. F 64.2	8. 16.2	—— ——	Meat meal.
5544	Jacob Dold Packing Co., Buffalo, N. Y. "Dold Quality Meat Meal"	Buffalo	G 46. F 51.1	10. 12.7	—— ——	Meat meal.

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	ANIMAL POULTRY FOODS (*continued*):					
6216	Jacob Dold Packing Co., Buffalo, N. Y. " Dold Quality Meat Scrap "	Buffalo	G* 50. F* 49.8	8. 9.9	—— ——	Scraps of meat cooked and dried. Meat and bone scrap.
6138	Jacob Dold Packing Co., Buffalo, N. Y. " Dold Quality Meat Scrap "	Oxford	G 50. F 50.7	8. 13.3	—— ——	Scraps of meat cooked and dried. Meat and bone scrap.
5554	Jacob Dold Packing Co., Buffalo, N. Y. " Dold Quality Poultry Bone "	Chatham	G 24. F 26.2	5. 2.9	—— ——	Granulated bone.
5545	Jacob Dold Packing Co., Buffalo, N. Y. " Dold Quality Soluble Blood Flour "	Buffalo	G 87. F 88.6	—— .6	—— ——	Blood meal.
5538	Economy Meat Food Co., Gardenville, N. Y. " Economy Meat Scrap "	Gardenville	G 55. F 49.9	8. 9.7	—— ——	Meat and bone scrap.
6009	Geo. M. Finn, Syracuse, N. Y. "Ground Beef and Bone Scrap Chicken Feed "	Moravia	G 35. F 39.9	15. 23.2	—— ——	Meat and bone scrap.
6323	Geo. M. Finn, Syracuse, N. Y. " Ground Beef and Bone Scrap Chicken Feed "	Marion	G 35. F 39.	15. 20.6	—— ——	Meat and bone scrap.

5773	The Flavell Co., Asbury Park, N. J. " V. I. M. Pure Beef Cracklings "	Cortland	G F	50. 50.3	15. 16.1	3. ——	Meat and bone scraps.
5512	Globe Elevator Co., Buffalo, N. Y. " Blue Ribbon Beef Scrap for Poultry "	Buffalo	G F	50. 46.7	6. 11.8	—— ——	Meat and bone scrap.
5635	International Glue Co., Boston, Mass. " Red Star Brand Fish Scrap "	Lebanon Spgs.	G F	45. 49.7	2. 2.2	—— ——	Fish scrap and bone.
6120	Lowell Fertilizer Co., Boston, Mass. " Bone and Meat Meal "	Cincinnatus	G F	35. 38.1	8. 9.2	—— ——	Meat and bone scrap.
6462	The Park & Pollard Co., Boston, Mass. "Blue Ribbon Meat Scraps "	Altamont	G F	45. 41.7	13. 11.3	2. ——	Meat and bone scrap.
6157	Quaker City Mfg. Co., Philadelphia, Pa. " Quaker City Brand Beef Scraps "	Ballston Spa.	G F	50. 48.8	10. 15.9	2. ——	Meat scrap.
5499	Reading Bone Fertilizer Co., Reading, Pa. " Reading Poultry Meat "	South Dayton	G F	55. 54.2	10. 2.8	3. ——	Meat and bone scrap.
6419	Robert A. Reichard, Allentown, Pa. " Reichard's Bone Meal "	Monroe	G F	25. 25.5	5. 9.5	3. ——	Bone meal. Contains some meat.
6412	Robert A. Reichard, Allentown, Pa. " Reichard's Standard Beef Scrap "	New Hampton	G F	45. 46.5	8. 13.	5. ——	Meat and bone scrap.

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	ANIMAL POULTRY FOODS (*concluded*):					
3893	D. W. Romaine, Jersey City, N. J. "D. W. Romaine's Evaporated Boiled Beef and Bone for Poultry"	Nanuet	G* 50. F* 45.9	17.85 16.3	1.80 ——	Meat meal.
6141	Spratt's Patent (America) Ltd., Newark, N. J. "Spratt's Patent Ground Meat"	Trumansburg	G 43. F 49.4	11. 11.3	2. ——	Ground meat. Meat and bone scrap.
5608	H. M. Stanton, Schenectady, N. Y. "Ground Beef Scraps"	Albany	G 40. F 42.	15. 23.1	—— ——	Meat and bone scrap.
6067	Stumpp & Walter Co., New York, N. Y. "Quality Kind Beef Scrap"	New York	G 50. F 50.1	10. 11.6	—— ——	Meat and bone scrap.
5475	Swift & Co., Chicago, Ill. Swift's Special Meat Scraps	Buffalo	G 50. F 46.6	8. 12.7	3. ——	Meat and bone scrap.
6335	Swift & Company, Newark, N. J. "Swift's Beef Scraps"	Odessa	G 50. F 50.7	10. 10.8	—— ——	Meat and bone scrap.
5755	Syracuse Rendering Co., Syracuse, N. Y. "Syracuse Bone and Meat Meal for Poultry"	Hooper	G 35. F 41.2	8. 14.4	—— ——	Meat meal.

6081	The Van Iderstine Co., Long Island City, N. Y. "Darling's Digester Tankage for Hogs"	Long Island City	G	60.	2.	3.	
			F	60.2	7.4	—	Meat and blood meal.
6176	The Van Iderstine Co., Long Island City, N. Y. "Darling's High Protein Meat Scrap for Poultry"	Poughkeepsie	G	55.	5.	3.	
			F	56.1	9.3	—	Meat and bone scrap.
6089	The Van Iderstine Co., Long Island City, N. Y. "Darling's Hog Cents Digester Tankage"	Long Island City	G	40.	2.	3.50	
			F	43.7	11.5	—	Meat meal.
6073	The Van Iderstine Co., Long Island City, N. Y. "Darling's Pure Ground Meat Meal for Poultry"	Long Island City	G	45.	5.	3.	
			F	46.6	11.5	—	Meat meal.
6186	The Van Iderstine Co., Long Island City, N. Y. "Darling's Pure Ground Meat Scraps"	Poughkeepsie	G	45.	8.	3.	
			F	48.8	8.7	—	Meat and bone scrap.
	POULTRY FOODS, COMPOUNDED:						
5547	Acme Milling Co., Olean, N. Y. "Acme Dry Mash"	Olean	G	13.	3.	4.	Corn meal, gluten meal, oil meal, wheat, bran and middlings, and hen-e-ta grits, salt and beef scrap.
			F	16.2	4.4	3.1	Corn meal, corn gluten meal, linseed meal, wheat bran, wheat middlings, meat and bone scraps, heneta grits, salt.
5650	Albany Rendering Co., Albany, N. Y. "Albany Poultry Food"	Watervliet	G	40.	8.	—	Prepared from cooked meat scraps.
			F	41.8	14.3	—	Meat and bone scrap.
5532	American Milling Co., Chicago, Ill. "Sucrene Chick Feed"	Olean	G	10.	3.	5.	Cracked corn, cracked kaffir corn, cracked feed wheat, millet and linseed oil cake.
			F	11.6	2.9	2.1	As certified.

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	POULTRY FOODS, COMPOUNDED (*con.*):					
5627	American Milling Co., Chicago, Ill. "Sucrene Scratch Feed with 5 per cent Grit"	Troy	G*10.	3.	5.	Cracked corn, feed wheat, kaffir corn, linseed oil cake, sunflower seed, buckwheat, barley and grit.
			F*10.5	3.2	2.2	Cracked corn, feed wheat, kaffir corn, sunflower seed, buckwheat, barley, grit.
6341	The Birkett Mills, Penn Yan, N. Y. "Victrix Egg Mash"	Penn Yan	G 19.	4.	4.	Ground beans, wheat bran, linseed meal, wheat middlings, corn meal and cottonseed meal.
			F 20.7	4.3	5.1	As certified.
5493	Blatchford Calf Meal Factory, Waukegan, Ill. "Blatchford's Fill the Basket Egg Mash"	North Collins	G 19.	4.	10.	Blatchford's calf meal (bean, cocoanut, flaxseed, cottonseed, locust bean, linseed oil and pea meals, fenugreek, wheat flour, dried milk, cocoa shells and salt), also alfalfa, barley, bone, corn and oat meals, wheat bran, wheat middlings, beef scraps, fish, capsicum and limestone grits.
			F 19.6	3.9	9.4	Bean meal, cocoanut meal, cottonseed meal, locust bean meal, linseed meal, pea meal, fenugreek, wheat flour, dried milk, ground cocoa shells, alfalfa, barley residue, bone meal, corn meal, ground oats, wheat bran, wheat middlings, beef scraps, fish scraps, pepper, grit, salt and rice hulls.

6054	Brooklyn Elevator & Milling Co., Brooklyn, N. Y. "Bemco Poultry Mash"	Brooklyn	G 12.	3.	5.	Corn meal, gluten meal, wheat bran, oil meal, wheat middlings, hen-e-ta grits.
			F 14.	4.1	4.7	Corn meal, corn gluten meal, wheat bran, wheat middlings, linseed meal, heneta grit.
5555	Buffalo Cereal Co., Buffalo, N. Y. "Bufceco Chick Feed"	Chatham	G 12.	2.	2.	Corn, wheat, kaffir corn, peas, milllet.
			F 12.1	2.9	1.3	Finely cracked corn, wheat, kaffir corn, peas, millet, oat groats.
6152	Buffalo Cereal Co., Buffalo, N. Y. "Bufceco Poultry Feed"	Watervliet	G 15.	4.	5.	Corn, hominy feed, wheat bran, wheat middlings, gluten feed, rolled oats.
			F 15.8	5.2	5.2	Corn meal, hominy feed, wheat bran, wheat middlings, corn gluten feed, rolled oats.
5514	Buffalo Poultry Supply Co., Buffalo, N. Y. "Buffalo Brand Laying Mash"	Buffalo	G 15.	4.	13.	Wheat bran, wheat midds, corn meal, gluten meal, alfalfa, beef scrap, red dog flour, oil meal and ground oats.
			F 13.9	5.2	4.5	Wheat bran, wheat middlings, corn meal, corn gluten meal, alfalfa meal, beef scraps, red dog flour, linseed meal, ground oats.
6502	Burlington Rendering Co., Burlington, Vt. "Burlington Poultry Food"	Glens Falls	G 40.	8.	——	Prepared from cooked meat scraps.
			F 44.3	12.2	——	Meat and bone scrap.
5667	The G. E. Conkey Co., Cleveland, O. "Conkey's Starting Food for Chicks"	Sidney	G 12.	4.	4.	Corn, wheat, wheat middlings, hulled oats, meat bone, salt, sulphur, iron sulphate, gentian root, bone ash and mustard seed.
			F 17.2	4.2	2.6	As certified.
6069	The A. Cyphers Co., Newark, N. J. "A Grade Cypho Chick Food"	New York	G 10.	2.	3.	Cracked corn, broken rice, buckwheat groats, millet seed, cut oats, cut kaffir corn, cut wheat, cut green peas.
			F 12.8	3.9	2.2	Cracked corn, kaffir corn, milo maize, broken rice, millet seed, oat groats, cracked wheat and rye, broken peas.

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ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	POULTRY FOODS, COMPOUNDED (*con.*):					
6088	A. Cyphers Co., Newark, N. J. "Cypho Morning Mash for Poultry, Grade A"	Lynbrook	G*12.	2.50	12.	Corn meal, wheat middlings, alfalfa meal, rolled oats, cottonseed meal, linseed meal, buckwheat middlings, ground charcoal, gluten meal and meat meal.
			F* 17.7	4.4	10.9	Ground kaffir corn, ground wheat, alfalfa meal, rolled oats, cottonseed meal, linseed meal, buckwheat middlings, buckwheat hulls, corn gluten meal, meat and bone meal, charcoal, small amount of weed seeds.
6084	A Cyphers Co., Newark, N. J. "Cypho Morning Mash for Poultry, Grade B"	Freeport	G 12.	2.50	12.	Ground corn, wheat, alfalfa, rolled oats, cottonseed meal, linseed meal, buckwheat midds, gluten meal and charcoal.
			F 16.6	4.1	11.3	Ground corn, ground wheat, alfalfa, rolled oats, ground kaffir corn, cottonseed meal, linseed meal, buckwheat middlings, buckwheat hulls, ground rice, meat meal, corn gluten meal, screenings consisting largely of whole weed seeds, charcoal.
5528	Cyphers Incubator Co., Buffalo, N. Y. "Fattening Mash"	Buffalo	G 11.	3.	5.	Kaffir meal, wheat bran, red dog, wheat middlings, corn meal, alfalfa meal.
			F 11.9	4.	3.	As certified.
5527	Cyphers Incubator Co., Buffalo, N. Y. "Fertile Egg Mash"	Buffalo	G 10.	3.	12.	Wheat bran, wheat middlings, ground oats, corn meal and alfalfa meal.
			F 12.3	3.8	4.4	As certified.

5479	Cyphers Incubator Co., Buffalo, N. Y. " Growing Mash "	Snyder	G	10.	3.	10.	Ground oats, corn meal, wheat middlings, meat and bone, alfalfa meal.
			F	15.8	4.9	3.4	Ground oats, corn meal, wheat middlings (meat, blood and bone meal), kaffir meal, alfalfa meal.
5462	Cyphers Incubator Co., Buffalo, N. Y. " Laying Mash "	Buffalo	G	15.	3.	6.	Kaffir meal, wheat bran, red dog, wheat middlings, corn meal, alfalfa meal and blood meal.
			F	15.9	3.9	2.9	Kaffir corn meal, wheat bran, wheat middlings, red dog flour, corn meal, blood meal.
6117	Dayton Milling Co., Towanda, Pa. " Dayton Laying Mash "	Waverly	G	12.	3.	9.	Gluten, middlings, corn meal, bran, ground oats, oil meal, alfalfa and heneta bone grits.
			F	12.9	3.2	5.9	Corn gluten feed, wheat bran and wheat middlings, corn meal, ground oats, linseed meal, alfalfa meal, heneta grits.
6161	The Albert Dickinson Co., Chicago, Ill. " Globe Egg Mash "	Schenectady	G	16.	3.	10.	Alfalfa meal, bran, middlings, wheat meal, corn feed meal, ground corn bran, oil cake, meat scraps, salt one-half of one per cent.
			F	17.9	4.2	5.6	Alfalfa meal, wheat bran, wheat middlings, wheat meal, corn feed meal, corn bran, linseed oil cake, meat and bone scrap, salt.
5643	The Albert Dickinson Co., Chicago, Ill., " Globe Scratch Feed "	Albany	G	10.	2.5	5.	Corn, wheat, rye, barley, oats, kaffir corn, buckwheat, sunflower, and oil cake.
			F	12.4	2.9	2.7	Cracked corn, wheat, rye, barley, oats, kaffir corn, buckwheat, sunflower seeds, and linseed oil cake.

'* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	POULTRY FOODS, COMPOUNDED (*con.*):					
5620	The Albert Dickinson Co., Chicago, Ill., "Queen Poultry Mash"	Schenectady	G*11.	2.50	10.	Alfalfa meal, corn feed meal, wheat meal, ground corn bran, wheat bran, meat scraps, oil cake, salt one-half of 1 per cent.
			F* 10.9	3.34	6.4	As certified.
5617	R. D. Eaton Grain & Feed Co., Norwich, N. Y. "Eaton's Perfection Mash Mixture for Laying Fowls"	Schenectady	G 20.	4.	8.	Alfalfa meal, milk albumen, milo maize meal, beef scraps, charcoal, winter wheat bran, kaffir corn meal, granulated bone, whole wheat flour, linseed oil meal, gluten, pea meal, bone flour, sodium chloride, ground oats, heneta grits.
			F 17.1	4.1	9.4	Alfalfa meal, milk albumin, milo maize, kaffir meal, meat scraps, granulated bone, bone meal, wheat, wheat bran, wheat middlings, linseed meal, corn gluten feed, pea meal, oats, charcoal, heneta grits, salt.
6156	Daniel Eddy & Sons, Saratoga Springs, N. Y. "Eddyson Dry Mash"	Saratoga Springs	G 12.	3.	4.	Corn meal, gluten, wheat middlings, wheat bran, pea meal, oil meal, heneta composed of phosphorus, silica, lime and soda.
			F 13.	3.1	3.8	Corn meal, corn gluten meal, wheat bran, wheat middlings, linseed meal, heneta grit.
6057	The L. T. Frisbie Co., New Haven, Conn. "Frisbie's Poultry Food"	Brooklyn	G 40.	8.	——	Prepared from cooked meat scraps.
			F 47.	10.7	——	Meat and bone scraps.

6086	William Germuth, Richmond Hill, N. Y. " Dunton Poultry Mash "	Lynbrook	G	17.38	4.64	7.30	Alfalfa meal, wheat middlings, wheat bran, corn meal, linseed meal, meat scraps.
			F	17.3	4.4	8.9	Alfalfa meal, wheat bran, wheat middlings, corn meal, meat scrap.
6200	G. W. Gerow, Vails Gate, N. Y. " Gerow's Poultry Mash "	Vails Gate	G	14.	4.	8.	Hominy, corn meal, gluten, wheat bran, shorts, shipstuff and meat scraps.
			F	15.5	6.1	5.6	Hominy feed, corn meal, corn gluten feed, wheat bran, wheat middlings, meat and bone scrap.
6007	Globe Elevator Co., Buffalo, N. Y., " Blue Ribbon Laying Mash "	Auburn	G	20.	3.	10.	Wheat bran, wheat midds, wheat flour, ground oats, corn meal, gluten meal, ground alfalfa, oil meal, meat meal, fish scrap, ground bone.
			F	21.5	4.8	7.5	Wheat bran, wheat middlings, wheat flour, oats, corn meal, corn gluten meal, alfalfa meal, linseed meal, pea meal, meat scrap, fish scrap, ground bone.
5515	Harvey Seed Co., Buffalo, N. Y. " Electric Poultry Food "	Dunkirk	G	12.	3.	——	Corn meal, wheat middlings, gluten feed, cottonseed meal, wheat bran and oil meal.
			F	15.3	4.2	4.1	Corn meal, wheat middlings, corn gluten feed, cottonseed meal, linseed meal.
4948	Hen-e-ta Bone Co., Newark, N. J. "Hen-O-La Dry Mash "	Auburn	G	12.	2.	4.	Corn meal, gluten, middlings, bran, oil meal and hen-e-ta (sodium, lime, phosphorus and silica).
			F	11.7	3.	4.4	Corn meal, corn gluten meal, wheat bran, wheat middlings, linseed meal, heneta grits.

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ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	POULTRY FOODS, COMPOUNDED (*con.*):					
4937	The Hen-ty Mfg. Co., Auburn, N. Y. "The Hen-ty Laying Mash"	Auburn	G*16.	5.	6.	Linseed meal, cottonseed meal, corn meal, wheat bran, wheat mids, ground oats, gluten feed, hominy meal, fish scraps, beef scraps, bone meal, meat meal, oyster shell meal, alfalfa meal, charcoal.
			F*17.6	5.40	6.	Linseed meal, cottonseed meal, wheat bran, wheat middlings, ground oats, corn gluten feed, hominy feed, fish scrap, beef scrap, bone meal, oyster shell meal, alfalfa meal, charcoal, corn meal.
6207	The H-O Company, Buffalo, N. Y. "The H-O Co's Algrane Scratching Feed"	Buffalo	G 11.	3.50	9.	Wheat, oats, kaffir corn, buckwheat, wheat screenings, cracked corn, milo maize, sunflower seed, hulled oats.
			F 12.2	3.4	2.3	Wheat, oats, kaffir corn, buckwheat, cracked corn, sunflower seeds, oat groats, wheat screenings.
6209	The H-O Company, Buffalo, N. Y. "The H-O Co's Chick Feed"	Buffalo	G 12.	3.	9.	Cracked corn, cut oat meal, cracked wheat, cracked kaffir corn, cracked peas, millet.
			F 13.9	4.6	2.1	Cracked corn, oat groats, cracked wheat, cracked kaffir corn, cracked peas, millet seed, charlock, foxtail, ladies thumb, wild buckwheat, flax seed.

6153	The H-O Company, Buffalo, N. Y. "The H-O Co's Dry Poultry Mash"	Troy	G	20.	3.5	9.	Oat midds, gluten feed, wheat midds, rolled oats, alfalfa, corn, hominy feed, cracked wheat, wheat bran.
			F	19.7	3.8	10.9	Rolled oats, oat middlings, corn gluten feed, wheat bran, wheat middlings, cracked wheat, cracked corn, hominy feed, alfalfa meal.
6154	The H-O Company, Buffalo, N. Y. "The H-O Co's Poultry Feed"	Troy	G	17.	5.5	9.	Ground corn, oat midds, gluten feed, wheat bran, rolled oats, wheat midds, hominy feed.
			F	17.9	5.5	6.2	Ground corn, rolled oats, oat middlings, corn gluten feed, wheat bran, wheat middlings, hominy feed.
6208	The H-O Company, Buffalo, N. Y. "The H-O Co's Steam Cooked Chick Feed"	Buffalo	G	12.	3.	9.	Cracked corn, cut oat meal, cracked wheat, cracked kaffir corn, cracked peas, millet.
			F	12.3	4.3	1.8	Cracked corn, oat groats, cracked wheat, cracked kaffir corn, millet seed.
6005	Husted Milling Co., Buffalo, N. Y. "Husted Laying Mash"	Auburn	G	15.	3.	8.	Corn meal, rolled oats, wheat bran, wheat middlings, cottonseed meal, gluten feed.
			F	16.7	3.5	5.2	As certified.
6221	Jamestown Electric Mills, Jamestown, N. Y. "Purity Poultry Mash"	Jamestown	G	12.	3.	3.50	Corn meal, diamond gluten, wheat middlings, wheat bran, O. P. oil meal, pea meal and hen-e-ta grits (composed of phosphorus, silica, lime, soda).
			F	13.4	3.4	3.9	Corn meal, corn gluten meal, wheat bran, wheat middlings, linseed meal, heneta grit.
5625	Lowell Fertilizer Co., Boston, Mass. "Lowell Poultry Food"	Troy	G	40.	8.	——	Prepared from cooked meat scrap.
			F	42.7	13.5	——	Meat and bone scrap.

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ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	POULTRY FOODS, COMPOUNDED (*con.*):					
5789	Mercer Milling Co., Baldwinsville, N. Y. " Heneta Mash "	Baldwinsville	G* ——	——	——	Wheat bran, Buffalo gluten, wheat middlings, corn meal, fine and coarse hen-e-ta.
			F* 12.2	3.	3.6	Wheat bran, wheat middlings, corn gluten feed, corn meal, linseed meal, heneta grit.
6436	Mystic Milling & Feed Co., Rochester, N. Y. "Puritan Growing Mash"	Rondout	G 14.	3.	8.	Wheat bran, wheat middlings, corn meal, gluten feed, alfalfa meal, bone meal, and meat meal.
			F 14.9	3.5	4.6	Wheat bran, wheat middlings, corn meal, kaffir corn meal, corn gluten feed, alfalfa meal, meat and bone meal.
6025	Mystic Milling & Feed Co., Rochester, N. Y. " Mystic Laying Mash "	Rochester	G 23.	4.	8.	Wheat middlings, corn meal, gluten feed, oil meal, alfalfa meal, blood meal, bone meal, wheat bran.
			F 22.4	5.4	6.	Wheat bran, wheat middlings, corn meal, corn gluten feed, linseed meal, alfalfa meal (meat, blood and bone meal).
6024	Mystic Milling & Feed Co., Rochester, N. Y. " Puritan Laying Mash "	Rochester	G 23.	7.	8.	Gluten, oil meal, bran, corn meal, middlings, alfalfa meal, bone meal, meat meal, blood meal.
			F 21.7	5.2	5.	Corn gluten feed, linseed meal, wheat bran, wheat middlings, corn meal, kaffir corn meal, alfalfa meal (meat, blood and bone meal).

6463	L. Newhof & Son, Albany, N. Y. "Poultry Food"	Albany	G	35.	10.	——	
			F	32.3	13.9	——	Meat and bone meal.
6033	A. Nowak & Son, Buffalo, N. Y.	Corning	G	12.	3.	5.	Ground corn, gluten feed, wheat bran, wheat middlings, and heneta (phosphorus, lime, sodium and silica).
	"Lay-Egg-O Dry Mash"		F	13.	4.	4.9	Ground corn, corn gluten feed, wheat bran, wheat middlings, heneta grit, small amount of kaffir corn.
6199	Wm. Orr & Sons, Orr's Mills, N. Y. "Orr's Digestible Mash"	Orrs Mills	G	8.	2.	15.	Corn meal, wheat bran, wheat middlings, alfalfa meal, beef scrap, oyster shells, beet pulp, ground oats, barley, gluten, bone meal, salt.
			F	17.2	4.6	6.7	White corn meal, wheat bran, wheat middlings, alfalfa meal, beef scrap, oyster shells, dried beet pulp, ground oats, barley, corn gluten feed, bone meal, salt.
5603	The Park & Pollard Co., Boston, Mass. "Fattening Feed"	Albany	G	10.	3.50	8.	Corn, wheat, barley, kaffir corn, oats and salt.
			F	10.4	4.1	8.	Corn meal, ground wheat, ground oats, oat hulls, ground barley, salt.
5604	The Park & Pollard Co., Boston, Mass. "Growing Feed"	Albany	G	10.	3.50	8.	Ground corn, wheat, barley, oats, meat, bone, alfalfa, kaffir corn, wheat bran, wheat middlings, buckwheat, beet pulp and salt.
			F	13.9	4.2	4.	As certified.
5606	The Park & Pollard Co., Boston, Mass. "Dry Mash"	Albany	G	18.	3.50	12.	Ground:—wheat bran, wheat middlings, corn, wheat, oats, barley, kaffir corn, buckwheat, alfalfa, fish, meat, bone, beet pulp and salt.
			F	13.4	3.3	4.2	Wheat bran, wheat middlings, corn, wheat, oats, barley, buckwheat, alfalfa, meat, meal and small amounts of fish, beet pulp, kaffir corn and salt.

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ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	POULTRY FOODS, COMPOUNDED (*con.*):					
6050	Purina Mills, St. Louis, Mo. "Purina Chicken Chowder Feed with Charcoal"	Elmira	G* 17.	3.	9.	Middlings, bran, corn meal, alfalfa meal, linseed meal, granulated meat.
			F* 18.9	4.8	6.6	Wheat bran, wheat middlings, corn meal, alfalfa meal, linseed meal, meat meal, kaffir corn meal, charcoal.
6406	The Quaker Oats Co., Chicago, Ill. "American Poultry Feed"	Goshen	G 12.	3.5	9.	Hominy feed, ground barley, cottonseed meal, wheat mixed feed and rye shorts.
			F 13.5	4.8	3.9	Hominy feed, ground corn, oats and barley, cottonseed meal, wheat bran, wheat middlings, rye middlings.
5662	The Quaker Oats Co., Chicago, Ill. "Schumacher Little Chick Feed"	Stamford	G 10.	2.50	5.	Made from cracked Indian corn, whole millet seed, cracked kaffir corn, cracked wheat, oat meal, charcoal and marble grit.
			F 11.3	3.3	2.6	As certified.
6177	Spratt's Patent (America), Ltd., Newark, N. J. "Spratt's Patent Egg Mash Food"	Poughkeepsie	G 24.	4.5	8.	Wheat bran, wheat, corn meal, alfalfa meal, ground meat, ground rice, ground kaffir corn, ground buckwheat, ground bone, ground charcoal, ground peas.
			F 24.5	6.2	5.7	Wheat bran, ground corn, kaffir corn meal, alfalfa meal, meat scrap, ground bone, ground rice, charcoal, small amounts of broken wheat, ground buckwheat, ground peas, millet seed.

6068	Stumpp & Walter Co., New York "Quality Kind Mash Food"	New York	G	15.	3.	12.	Ground corn, wheat and alfalfa, rolled oats, cottonseed meal, linseed meal, buckwheat middlings and meat meal.
			F	16.6	3.3	11.4	Ground corn, ground wheat, alfalfa, rolled oats, ground kaffir corn, cottonseed meal, linseed meal, buckwheat middlings, buckwheat hulls, ground rice, meat meal, corn gluten feed, screenings consisting largely of whole weed seeds.
6458	The Sugarine Co., Chicago, Ill. "Sugarine Chick Feed"	Oneonta	G	10.	3.	5.	Cracked corn, cracked kaffir corn, cracked feed wheat, millet and linseed oil cake.
			F	11.9	3.4	2.8	Fine cracked corn, cracked kaffir corn, cracked feed wheat, millet seed, flaxseed, wild buckwheat, foxtail, pig-weed, charlock, corn cockle.
5614	The Sugarine Co., Chicago, Ill. "Sugarine Scratch Feed"	Albany	G	10.	3.	5.	Cracked corn, feed, wheat, kaffir corn, linseed oil cake, sunflower seed, buckwheat and barley.
			F	12.	3.8	3.3	As certified.
6001	Syracuse Rendering Co., Syracuse, N. Y. "Syracuse Poultry Food"	Auburn	G	40.	8.	—	Prepared from cooked meat scraps.
			F	42.7	13.10	—	Meat and bone scrap.
6109	Syracuse Milling Co., Syracuse, N. Y. "Syragold Dry Mash"	Wampsville	G	12.	3.	5.	Wheat bran, wheat middlings, yellow corn meal, gluten feed, old process oil meal, heneta.
			F	12.1	3.1	4.9	Wheat bran, wheat middlings, corn meal, corn gluten feed, linseed meal, heneta grit.

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	POULTRY FOODS, COMPOUNDED (*con.*):					
6118	W. I. Teed's Sons, Sayre, Pa. " Teed's Ready Mixed Laying Mash "	Waverly	G* 18.	4.	8.	Gluten meal, white middlings, corn meal, beef scraps, oil meal, salt, wheat bran, ground oats, alfalfa meal, and charcoal.
			F* 19.4	4.8	6.3	Corn gluten meal, wheat bran, wheat middlings, corn meal, bone meal, beef scrap, linseed meal, ground oats, alfalfa meal, charcoal, salt.
6115	Tioga Mill & Elevator Co., Waverly, N. Y. " Tioga Dry Mash "	Waverly	G 13.	3.75	5.25	Corn meal, corn germ, linseed meal, wheat flour, wheat bran, gluten feed, wheat middlings, kaffir corn meal, phospho silicate of lime and soda.
			F 13.4	2.8	3.5	Corn meal, corn germ, linseed meal, wheat bran, wheat middlings, wheat flour, corn gluten feed, kaffir corn meal, heneta grit.
6080	The Van Iderstine Co., Long Island City, N. Y. " Darling's Mash Food for Poultry "	L. Island City	G 18.	3.50	10.	Cracked corn, meat scraps, blood meal, alfalfa meal, wheat middlings, wheat bran, oyster shells and grit.
			F 18.1	4.6	5.6	Finely cracked corn, kaffir corn, meat scraps, blood meal, bone meal, alfalfa meal, wheat bran, wheat middlings, ground oyster shells.
6426	L. R. Wallace, Middletown, N. Y. " Mapes Balanced Ration for Poultry "	Middletown	G 12.	4.	8.	Animal meal, ground bone, corn meal, wheat middlings, wheat bran, gluten feed, ground oats and alfalfa meal.
			F 12.8	4.1	4.4	Meat meal, bone meal, corn meal, wheat bran, wheat middlings, ground oats, alfalfa meal.

	Miscellaneous Feeds:						
6457	The Alfalfa Products Co., Superior, Neb. "Superior Alfalfa Meal"	Oneonta	G F	13. 13.4	1.50 1.5	28.40 32.2	Alfalfa meal. Alfalfa meal.
6116	American Milling Co., Chicago, Ill. "Amco Alfalfa Meal"	Waverly	G F	13. 14.6	2. 1.2	30. 27.9	Alfalfa hay. Alfalfa meal.
6416	American Hominy Co., Philadelphia, Pa. "Maizeline Feed"	Walden	G F	7. 10.1	4. 8.8	13. 6.2	Corn bran.
6340	The Birkett Mills, Penn Yan, N. Y. "Buckwheat Offal Feed"	Penn Yan	G F	12.50 11.	2.75 2.5	32. 34.3	Buckwheat hulls and buckwheat middlings.
6027	Buffalo Cereal Co., Buffalo, N. Y. "Yellow B Corn Meal"	So. Alabama	G F	—— 11.3	—— 7.6	—— 4.5	Corn feed meal.
6337	F. C. Campbell, Alpine, N. Y. "Buckwheat Feed"	Alpine	G F	—— 21.6	—— 5.5	—— 15.	All of buckwheat hulls and middlings. As certified.
4927	Cataract City Milling Co., Niagara Falls, N. Y. Niagara White Middlings"	Geneva	G F	15.92 16.9	5. 5.59	—— 6.3	Wheat middlings. Wheat middlings.
4922	L. Christian & Co., Minneapolis, Minn. "Pure Wheat Bran"	Elmira	G F	15. 15.06	4. 5.16	10. 10.22	Wheat bran.
6135	H. C. Cole Milling Co., Chester, Ill. "Bran"	Oxford	G F	14. 15.4	4. 4.7	10. 7.1	Wheat bran only. Wheat bran.

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	MISCELLANEOUS FEEDS (*continued*):					
6162	The Colorado Alfalfa Products Co., Kansas City, Mo. "Alfalfa Meal"	Schenectady	G* 12. F* 15.9	1. 1.8	35. 27.5	Alfalfa meal.
6004	The Colorado Alfalfa Products Co., Lamar, Colo. "'Algren' Alfalfa Meal"	Auburn	G 12. F 15.5	1. 2.4	35. 25.9	Alfalfa meal. Alfalfa meal.
6217	Cyphers Incubator Co., Buffalo, N. Y. "Mealed Alfalfa"	Buffalo	G 12. F 19.2	1. 3.4	30. 14.2	Alfalfa meal.
5621	The Albert Dickinson Co., Chicago, Ill., "Alfalfa Meal"	Schenectady	G 12. F 16.3	1. 2.3	35. 25.4	Made from alfalfa hay. Alfalfa meal.
5968	B. A. Eckhart Milling Co., Chicago, Ill. "Bran and Screenings"	North Java	G 14. F 17.	3. 5.3	— 7.6	Bran and screenings. Wheat bran.
6322	B. A. Eckhart Milling Co., Chicago, Ill. "Bran and screenings"	Marion	G 14. F 15.5	3. 5.	— 9.3	Bran and screenings. Wheat bran.
6019	Everett, Aughenbaugh & Co., Waseca, Minn. "Eaco Winged Horse Bran"	Port Byron	G 14. F 15.9	3. 5.8	12. 9.8	Wheat bran.

5489	J. Gorman, Buffalo, N. Y. "Boat Sweepings"	Buffalo	G	5.	2.	14.	This commodity is composed of sweepings from boats loaded with flour and feed and consists of several materials having feeding stuffs value, but it is impossible to name each ingredient contained therein.
			F	16.3	4.	5.2	Boat sweepings, containing wheat bran, wheat middlings, wheat flour, small amounts of wheat, corn, brewers' dried grains, and corn gluten feed, and a fairly large amount of weed seeds, distillers' dried grains.
6559	The Harter Milling Co., Toledo, O. "Wheat Bran"	Bangor	G	15.	4.	9.	
			F	15.7	4.8	8.5	Wheat bran.
5993	Harvey Seed Co., Buffalo, N. Y. "Alfalfa Meal"	Geneseo	G	12.	1.	30.	Made from alfalfa hay.
			F	15.5	2.4	26.2	Alfalfa meal.
6223	Henry & Missert, Buffalo, N. Y. "Malt Feed"	Buffalo	G	15.75	3.02	11.23	Barley malt and by-product.
			F	17.9	2.7	12.1	Barley malt and by-products, which consist largely of barley hulls and malt sprouts.
6211	The H-O Company, Buffalo, N. Y. "Force Screenings"	Buffalo	G	11.	3.	9.	Wheat and salt.
			F	16.9	6.8	2.9	As certified.
6329	B. A. Hopkins' Sons, Sodus, N. Y. "Buckwheat Bran"	Sodus	G	——	——	——	All of shucks and middlings.
			F	21.7	5.5	19.4	Buckwheat hulls and buckwheat middlings.
5633	Hottelet & Co., Milwaukee, Wis. "Dried Beet Pulp"	Stephentown	G	8.	.5	20.	
			F	8.8	1.2	18.3	Dried beet pulp.

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.		Crude protein.	Crude fat.	Crude fiber.	Ingredients.
				Per ct.	*Per ct.*	*Per ct.*	
	MISCELLANEOUS FEEDS (*continued*):						
6038	Harvey C. Howe, Southport, N. Y. "Buckwheat Hulls and Middlings"	Southport	G*	——	——	——	Buckwheat hulls and middlings.
			F*	14.9	4.5	11.8	Buckwheat middlings, buckwheat hulls.
6334	A. T. Kelsey, Mecklenburg Mills, Mecklenburg, N. Y. "Buckwheat Feed"	Mecklenburg	G	——	——	——	Buckwheat hulls, all of them, and buckwheat middlings.
			F	19.1	4.7	22.6	As certified.
6136	Kemper Mill & Elevator Co., Kansas City, Mo. "Diamond (K) Bran"	Oxford	G	14.50	4.	10.	Made from pure wheat.
			F	14.7	4.8	9.1	Wheat bran.
5505	Kornfalfa Feed Milling Co., Kansas City, Mo. "Pioneer Alfalfa Meal"	Kennedy	G	12.	1.50	30.	
			F	16.9	1.9	28.2	Alfalfa meal.
6425	Chas. A. Krause Milling Co., Milwaukee, Wis. "Badger Corn Oil Meal"	Chester	G	16.	7.	6.	Made from white corn.
			F	16.2	10.7	3.9	Corn germ meal.
6415	Chas. A. Krause Milling Co., Milwaukee, Wis. "Choice Alfalfa Meal"	Walden	G	14.	1.	30.	
			F	15.5	1.7	27.6	Alfalfa meal.
5534	The Larabee Flour Mills Co., Hutchinson, Kan. "Wheat Bran, Screenings and Corn Bran"	Friendship	G	12.	2.5	14.	
			F	16.8	4.1	8.2	Wheat bran.

5623	The Larrowe Milling Co., Detroit, Mich. "Dried Beet Pulp"	Troy	G	8.	.5	20.	Composed only of residue of sugar beets dried after extraction of sugar.
			F	8.2	.79	17.	Dried beet pulp.
6121	Geo. Q. Moon & Co., Binghamton, N. Y. "Alfalfa Meal"	Cincinnatus	G	——	——	——	
			F	14.1	1.8	30.	Alfalfa meal.
4926	Moseley & Motley Milling Co., Rochester, N. Y. "Choice Wheat Bran"	Geneva	G	——	——	——	Choice wheat bran.
			F	17.5	5.97	8.4	Wheat bran.
6013	National Alfalfa Millers' Ass'n, Kansas City, Mo. "'Algren' Alfalfa Meal"	Auburn	G	12.	1.	35.	
			F	15.7	2.4	23.7	Alfalfa meal.
4939	National Alfalfa Millers' Ass'n, Kansas City, Neb. "'Algren' Alfalfa Meal"	Auburn	G	12.	1.	35.	
			F	13.8	1.79	30.1	Alfalfa meal.
5799	National Feed Co., St. Louis, Mo. "Pure Alfalfa Meal"	Bainbridge	G	14.	1.25	33.	
			F	16.1	1.8	27.	Alfalfa meal.
6601	National Milling Co., Toledo, O. "National Feed"	Stormville	G	16.	3.75	8.50	
			F	17.3	4.7	7.4	Wheat bran.
6602	National Milling Co., Toledo, O. "Osota Mixed Feed"	Stormville	G	17.	4.50	8.	Pure wheat bran and pure wheat middlings.
			F	16.9	5.	5.8	Wheat bran, wheat middlings.
5523	Omaha Alfalfa Milling Co., Omaha, Neb. "Alfalfa Meal"	Buffalo	G	12.	1.	25.	
			F	18.3	2.	27.5	Alfalfa meal.
5485	The Otto Weiss Alfalfa Stock Food Co., Wichita, Kan. "Pure Dustless Alfalfa Meal"	Buffalo	G	14.	1.5	30.	
			F	17.3	2.02	27.	Alfalfa meal.

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF SAMPLES OF FEEDING STUFFS (*continued*).

Number.	Name and address of manufacturer or jobber and brand or trade name.	Where taken.	Crude protein.	Crude fat.	Crude fiber.	Ingredients.
			Per ct.	*Per ct.*	*Per ct.*	
	MISCELLANEOUS FEEDS (*concluded*):					
5605	The Park & Pollard Co., Boston, Mass. "Alfalfa"	Albany	G* 12. F* 14.3	1.50 1.54	30. 25.9	Alfalfa meal.
6332	George B. Paterson, Burdett, N. Y. "Buckwheat Feed"	Burdett	G 18.9 F 19.2	4.89 4.8	25. 22.	Buckwheat hulls, middlings and bran. As certified.
6108	M. C. Peters Mill Co., Omaha, Neb. "Lucern Pure Ground Alfalfa"	Cazenovia	G 11. F 15.	1. 1.9	33. 28.4	Alfalfa meal.
6316	The Pilliod Milling Co., Swanton, O. "Yellow Feed Meal"	Gates	G —— F 9.6	—— 5.	—— 3.3	Corn feed meal.
5550	Russell Grain Co., Kansas City, Mo. "Square Deal Alfalfa Meal"	Olean	G 12. F 16.	1.8 1.9	25. 23.4	Alfalfa meal.
5777	Ryan Bros., Jamesville, N. Y. "Barley Midds"	Syracuse	G 12. F 14.	3.50 3.9	7.80 7.2	Barley by-products, consisting of barley middlings, barley hulls and barley.
5780	A. V. Smith & Bro., Marcellus Falls, N. Y. "Barley Middlings"	Marcellus Falls	G 13. F 13.8	3. 4.6	12. 9.	Barley by-products consisting of barley, barley middlings, barley hulls and barley.
6133	Sparks Milling Co., Terre Haute, Ind. "Wabash Mixed Feed"	Whitney's Point	G 14. F 15.1	3.50 4.8	8. 6.9	Wheat bran and screenings. Wheat bran.

6405	Thompson & Mould, Goshen, N. Y. "Corn Bran"	Goshen	G F	8. 12.4	5. 9.9	14. 7.4	Corn bran, corn germ.
6137	Tioga Mill & Elevator Co., Waverly, N. Y. "White Wheat Ti-o-ga Middlings"	Oxford	G F	— 17.2	— 5.	— 4.7	Wheat middlings.
6330	Westbury Milling Co., Red Creek, N. Y. "Buckwheat Bran"	Red Creek	G F	— 16.	— 3.7	— 24.5	Buckwheat hulls, flour and middlings. As certified.
6191	(Not given) "Alfalfa Meal"	Fishkill-on-Hudson	G F	— 14.5	— 1.6	— 29.7	Alfalfa meal.

* These letters indicate, respectively, Guaranteed and Found.

REPORT OF ANALYSES OF SAMPLES OF COMMERCIAL FERTILIZERS COLLECTED BY THE COMMISSIONER OF AGRICULTURE DURING 1914.*

There are presented in this bulletin the analyses of samples of fertilizers collected by the Commissioner of Agriculture during 1914, and transmitted by him for analysis to the Director of the New York Agricultural Experiment Station, in accordance with the provisions of Article 9 of the Agricultural Law. These analyses and the accompanying information are published by said Director in accordance with the provisions of Section 224 of said Law.

Since many requests have been received for such data, it has been deemed best to give figures showing the current values of fertilizer ingredients, with an illustration of the method of applying these figures in determining the approximate commercial valuation of the different brands.

TRADE-VALUES OF PLANT-FOOD ELEMENTS IN RAW MATERIALS AND CHEMICALS.

The trade-values in the following schedule have been agreed upon by the Experiment Stations of Massachusetts, Rhode Island, Connecticut, New York, New Jersey and Vermont, as a result of study of the prices actually prevailing in the large markets of these states.

These trade-values represent, as nearly as can be estimated, the average prices at which, during the six months preceding March, the respective ingredients, *in the form of unmixed raw materials*, could be bought at retail for cash in our large markets. These prices also correspond (except in case of available phosphoric acid) to the average wholesale prices for the six months preceding March, plus about 20 per ct., in case of goods for which there are wholesale quotations.

* Reprint of Bulletin No. 390, October.

TRADE-VALUES OF PLANT-FOOD ELEMENTS IN RAW MATERIALS AND CHEMICALS.

	1914. Cts. per pound.
Nitrogen in nitrates and ammonium salts	$16\frac{1}{2}$
Organic nitrogen in dry and fine-ground fish, meat and blood	$22\frac{1}{2}$
" in fine-ground bone and tankage	$21\frac{1}{2}$
" in coarse bone and tankage	$17\frac{1}{2}$
" in castor pomace and cottonseed meal	$22\frac{1}{2}$
" in mixed fertilizers	$19\frac{1}{2}$
Phosphoric acid, water-soluble	$4\frac{1}{2}$
" citrate-soluble (reverted)	4
" in fine-ground fish, bone and tankage	4
" in cottonseed meal and castor pomace	4
" in coarse fish, bone, tankage and ashes	$3\frac{1}{2}$
" in mixed fertilizers, insoluble in ammonium citrate or water	2
Potash as high-grade sulphate, in forms free from muriates (chlorides), in ashes, etc	5
" in muriate	4
" in castor pomace and cottonseed meal	5

VALUATION AND COST OF FERTILIZERS.

The total cost (to the farmer) of a ton of commercial fertilizer may be regarded as consisting of the following elements: (1) Retail cash cost, in the market, of unmixed trade materials; (2) cost of mixing; (3) cost of transportation; (4) storage, commissions to agents and dealers, selling on long credit, bad debts, etc. While the *total cost* of a fertilizer is made up of several different elements, a *commercial valuation* includes only the first of the elements entering into the total cost, that is, the retail cash cost in the market of unmixed raw materials.

VALUATION AND AGRICULTURAL VALUE.

The *agricultural value* of a fertilizer depends upon its *crop-producing power*. A commercial valuation does not necessarily have any relation to crop-producing value on a given farm. For a particular soil and crop, a fertilizer of comparatively low commercial valuation may have a higher agricultural value; while, for another crop on the same soil, or the same crop on another soil, the reverse might be true.

RULE FOR CALCULATING APPROXIMATE COMMERCIAL VALUATION OF MIXED FERTILIZERS ON BASIS OF TRADE-VALUES FOR 1914.

Multiply the percentage of nitrogen by 3.9.
Multiply the percentage of available phosphoric acid by 0.9.
Multiply the percentage of insoluble phosphoric acid (total minus available) by 0.4.
Multiply the percentage of potash by 1.0.

The sum of these 4 products will be the commercial valuation per ton on the basis taken.

Illustration.— The table of analyses shows a certain fertilizer to have the following composition: Nitrogen 2.52 per ct.; available phosphoric acid 6.31 per ct.; insoluble phosphoric acid .89 per ct.; potash 6.64 per ct. According to this method of valuation, the computation would be as follows:

Nitrogen	2.52 x 3.8	$9.83
Available phosphoric acid	6.31 x 0.9	5.70
Insoluble phosphoric acid	0.89 x 0.4	0.36
Potash	6.64 x 1.0	6.64
		$22.53

This rule assumes all the nitrogen to be organic and all the potash to be in the form of sulphate. If a considerable portion of nitrogen exists in the fertilizer as nitrate of soda or as sulphate of ammonia, and potash is present as muriate, the results are somewhat less.

Farmers should be warned against judging fertilizers by their valuations. A fertilizer, the cost of which comes chiefly from the phosphoric acid present, would value much lower commercially than a fertilizer with a high percentage of nitrogen, and yet the former might be the more profitable one for a given farmer to purchase.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914.

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid — Available	Phosphoric acid — Total	Potash
Alphano Humus Co., New York, N. Y.						
Prepared Alphano Humus		G*	——	——	——	——
Binghamton	5882	F*	1.68	0.14	0.29	0.33
American Agricultural Chemical Co., New York, N. Y.						
Acme Fertilizer No. 2		G	4.94	8	9	5
Jamaica	5421	F	4.93	8.95	9.69	5.56
Acme No. 1 Potato Manure		G	3.29	6	7	10
New York	5546	F	3.30	5.99	7.65	9.92
Acme Special Potato and Truck		G	3.29	8	9	7
Hicksville	5424	F	3.31	8.38	9.76	7.32
Bone Meal		G	1.65	——	13.73	——
Cortland	4439	F	2.08	——	15.82	——
Bradley's Alkaline Phosphate and Potash		G	——	10	11	2
Nichols	6311	F	——	10.76	11.16	3.98
Bradley's Bay State		G	1.65	5	6	10
De Ruyter	6388	F	1.78	8.64	8.86	10.70
Bradley's B. D. Guano		G	0.82	8	9	4
Margaretville	6404	F	1.20	8.66	9.76	3.95
Bradley's Circle Phosphate		G	——	10	11	8
Nichols	6309	F	——	10.57	11.29	8.14
Bradley's Greyhound Fertilizer		G	3.29	6	7	10
Cortland	4442	F	3.31	6.55	7.27	10.64
Bradley's Half Century Fertilizer		G	2.06	8	9	3
Albany	5210	F	2.16	9.32	10.84	3.43
Bradley's King Philip		G	1.03	8	9	2
Berne	5233	F	1.28	8.32	10.14	2.20
Bradley's Magic Phosphate		G	——	12	13	5
Nichols	6310	F	——	12.20	13.26	4.88

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
AMERICAN AGRICULTURAL CHEMICAL Co., NEW YORK, N. Y. (*continued*).						
Bradley's Maize Producer		G*	2.06	8	9	6
Seneca Castle	4781	F*	2.04	9.33	10.21	7.08
Bradley's New Method Fertilizer		G	0.82	8	9	2
Berne	5234	F	1.02	8.45	9.95	2
Bradley's New Rival Fertilizer		G	1.23	6	7	5
De Ruyter	6387	F	1.26	7.64	9.56	6.08
Bradley's Niagara Phosphate		G	0.82	7	8	1
Central Bridge	5654	F	1.23	7.95	9.37	1.86
Bradley's Patent Superphosphate		G	2.06	8	9	1.50
Central Bridge	5655	F	2.04	8.46	9.88	2.38
Bradley's Potato and Vegetable Manure		G	3.29	8	9	7
Albany	5211	F	3.57	8.81	9.95	7.36
Bradley's Retriever Manure		G	2.47	6	7	5
Marathon	6382	F	2.45	6.49	7.97	5
Bradley's Superior Compound		G	0.82	9	10	7
Schuylerville	5664	F	1.03	9.06	11.48	6.84
Bradley's Tobacco Manure		G	4.53	3	4	5.50
Cato	6514	F	4.82	3.61	4.21	5.28
Bradley's Unicorn		G	1.65	8	9	2
Margaretville	6405	F	1.39	9.67	10.71	2.58
Bradley's Weymouth Staple Phosphate		G	1.65	8	9	10
Margaretville	6406	F	1.33	8.60	9.67	9.67
Canner's Pea and Bean Special Fertilizer		G	0.82	7	8	9
Orchard Park	5023	F	0.98	6.21	7.56	8.96
Champion Cereal Mixture		G	1.65	8	9	4
Cato	6513	F	2.08	8.21	9.63	3.94

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER			
			Nitrogen	Phosphoric acid Available	Phosphoric acid Total	Potash
AMERICAN AGRICULTURAL CHEMICAL CO., NEW YORK, N. Y. (*continued*)						
Clark's Cove King Philip Alkaline Guano		G*	1.03	8	9	2
Orchard Park	5021	F*	0.98	7.97	9.37	2.34
Crocker's Ammoniated Superphosphate		G	2.47	9	11	2
Dundee	4753	F	2.43	10.16	10.78	2.70
Crocker's Cabbage and Potato Manure		G	2.47	8	9	6
Union Hill	6035	F	2.14	7.19	9.49	5.88
Crocker's Century Fertilizer		G	1.65	5	6	10
Cherry Valley	5240	F	1.79	4.86	5.86	11.20
Crocker's Colonial Fertilizer		G	2.47	6	7	10
Ionia	6006	F	2.44	6.79	7.71	10.44
Crocker's Complete Manure		G	0.82	8	9	4
Carthage	5181	F	0.98	8.36	9.56	4.59
Crocker's Dissolved Phosphate and Potash		G	——	10	11	2
Cherry Valley	5232	F	——	10.36	11.16	2.60
Crocker's General Crop Fertilizer		G	0.82	7	8	1
Cherry Valley	5235	F	1.14	7.68	9.18	3.77
Crocker's Globe Phosphate		G	——	10	11	8
Carthage	5175	F	——	10.34	10.84	8.42
Crocker's Grain Grower		G	1.65	10	11	4
Boonville	5568	F	1.38	11.43	12.68	3.96
Crocker's Harvest Jewel Fertilizer		G	1.65	8	9	2
Hornell	4531	F	1.71	7.92	8.80	2.56
Crocker's High Grade Potato Fertilizer		G	3.29	6	7	10
Lodi	6537	F	3.27	6.58	7.84	9.68
Crocker's High Grade Special		G	1.65	8	9	4
Cherry Valley	5238	F	1.74	8.58	9.82	4.30

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer: Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
AMERICAN AGRICULTURAL CHEMICAL CO., NEW YORK, N. Y. (*continued*)						
Crocker's Nobsque Guano		G*	1.03	8	9	2
Palmyra	5363	F*	1.05	7.67	9.28	2.48
Crocker's Paragon Phosphate		G	——	12	13	5
Castile	4525	F	——	12.10	12.50	4.54
Crocker's Perfection Fertilizer		G	1.65	8	9	10
Cincinnatus	6373	F	1.66	8.58	9.24	9.74
Crocker's Rainbow Phosphate		G	2.06	8	9	3
Boonville	5565	F	2.43	7.99	8.99	5.97
Crocker's Root and Vine		G	0.82	9	10	7
Cortland	4441	F	1.11	8.67	9.69	10.54
Crocker's Special Potato Manure		G	3.29	8	9	7
Cherry Valley	5239	F	3.13	8.34	9.24	7.42
Crocker's Universal Grain Grower		G	0.82	8	9	2
Boonville	5566	F	1.15	8.17	9.37	2.28
Crocker's Wheat and Corn Fertilizer		G	2.06	8	9	1.50
Cherry Valley	5237	F	2.02	9.07	10.39	2.46
Darling's Blood, Bone and Potash		G	4.11	7	8	7
Laurel	5496	F	4.23	6.78	8.42	6.88
Darling's Long Island "A"		G	3.29	8	9	7
Hicksville	5440	F	3.27	8.36	9.56	7.30
Double Strength Manure		G	3.29	8	9	10
Johnstown	5136	F	3.46	7.56	9.21	9.50
East India Corn King		G	2.47	8	9	6
Poughkeepsie	4805	F	2.60	8.80	9.98	6.04
East India Economizer Phosphate		G	0.82	8	9	2
Poughkeepsie	4804	F	1.01	8.85	10.55	1.91
East India Farm Favorite		G	——	10	11	8
Cortland	4434	F	——	10.10	11.40	8.70

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid		Potash
				Available	Total	
American Agricultural Chemical Co., New York, N. Y. (*continued*)						
East India Fruit Growers Friend		G*	0.82	9	10	7
Cortland	4436	F*	1.07	9.89	11.03	7.04
East India Garden and Farm Manure		G	3.29	8	9	7
East Marion	5527	F	3.43	8.03	9.31	6.96
East India Improved Compound		G	1.65	5	6	10
Deposit	5847	F	1.65	5.95	7.27	9.94
East India Mayflower		G	1.65	8	9	2
Mapleton	6520	F	1.84	9.06	10.20	2.10
East India Monarch Phosphate		G	——	12	13	5
Apalachin	5886	F	——	12.42	13.17	4.64
East India Potato Manure		G	3.29	6	7	10
Apalachin	5870	F	3.35	6.79	7.65	10.22
East India Roanoke Phosphate		G	1.03	8	9	2
Sherburne	5806	F	1.19	8.26	9.76	2.24
East India 10% Vegetable and Potato		G	1.65	8	9	10
Cortland	4435	F	1.78	8.83	9.95	10.02
East India Tiger Brand		G	1.23	6	7	5
Nelson	5840	F	1.20	6.37	7.59	6.06
East India Unexcelled Fertilizer		G	2.06	8	9	3
Nelson	5841	F	2.36	7.98	9.24	3.24
East India Vegetable, Vine and Potato		G	2.47	6	7	10
Sherburne	5805	F	2.45	6.04	7.78	9.73
East India Victor Special		G	3.29	8	9	10
Cortland	4437	F	3.28	9	10.20	10.20
Fine Ground Bone		G	2.47	——	22.88	——
Freeport	5412	F	2.31	——	21.56	——
14% Acid Phosphate		G	——	14	15	——
West Haverstraw	5474	F	——	14.61	15.43	——

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer: Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
American Agricultural Chemical Co., New York, N. Y. (*continued*)						
14% Acid Phosphate		G*	——	14	15	——
South Plymouth	6312	F*	——	14.18	14.92	——
Genuine German Kainit		G	——	——	——	12
Cooperstown	5551	F	——	——	——	13.67
Genuine German Kainit		G	——	——	——	12
Chittenango Sta.	5815	F	——	——	——	14.40
Grass and Lawn Top Dressing		G	3.91	5	6	2
Poughkeepsie	4806	F	4.04	6.83	8.16	1.92
Grass and Lawn Top Dressing		G	3.91	5	6	2
Central Bridge	5656	F	2.88	6.24	7.86	2.94
Great Eastern Dissolved Acid Phosphate		G	——	14	15	——
Oquaga Lake	5874	F	——	14.85	15.38	——
Great Eastern English Wheat Grower		G	0.82	8	9	2
Unadilla	5772	F	1.02	8.38	9.76	2.02
Great Eastern Garden Special		G	3.29	8	9	7
Jamaica	5420	F	3.41	8.26	9.56	7.14
Great Eastern General		G	0.82	8	9	4
Delanson	5133	F	0.94	7.94	9.56	4.02
Great Eastern General		G	0.82	8	9	4
Salem	5665	F	1.22	8.20	9.44	6.30
Great Eastern New York Potato Special		G	1.65	8	9	10
Afton	5826	F	1.57	8.11	9.24	10.74
Great Eastern Northern Corn Special		G	2.47	9	10	2
Unadilla	5774	F	2.77	8.65	9.82	2.96
Great Eastern Peerless Potato Manure		G	1.03	7	8	10
Clayton	5714	F	1.20	7.73	8.67	9.35

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
AMERICAN AGRICULTURAL CHEMICAL CO., NEW YORK, N. Y. (*continued*)						
Great Eastern Schodack Special		G*	0.82	9	10	7
Unadilla	5775	F*	1	9.33	10.33	6.51
Great Eastern Soluble Bone and Potash		G	——	11	12	2
Salem	5666	F	——	10.22	11.60	2.70
Great Eastern Unammoniated Wheat Special		G	——	12	13	——
Sherburne	5801	F	——	12.10	13.38	——
Great Eastern Vegetable, Vine and Tobacco Fertilizer		G	2.06	8	9	3
Clayton	5713	F	2.44	6.49	7.62	6.21
Ground Tankage		G	7.40	——	9.15	——
Elmira	4789	F	7.31	——	10.52	——
Ground Tankage 6–30		G	4.94	——	13.73	——
New York	5547	F	5.30	——	15.88	——
Ground Tankage 6–30		G	4.94	——	13.73	——
Tarrytown	5626	F	5.05	——	14.22	——
Ground Untreated Phosphate Rock		G	——	——	31.12	——
Chester	5689	F	——	——	33.54	——
High Grade Dried Blood		G	9.87	——	——	——
Brockport	5354	F	9.05	——	——	——
High Grade Ground Bone		G	3.29	——	20.59	——
Colden	5078	F	3.65	——	20.92	——
High Grade Potash Compound		G	1.65	8	9	10
Castile	4526	F	1.77	8.60	9.31	10.52
High Grade Sulphate of Potash		G	——	——	——	48
Castile	4524	F	——	——	——	52.70

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
AMERICAN AGRICULTURAL CHEMICAL CO., NEW YORK, N. Y. (*continued*)						
Lazaretto "AA" Superphosphate		G*	1.85	9	10	4
Union Hill	6029	F*	1.89	8.83	10.33	4.12
Lazaretto Alkaline Dissolved Bone		G	——	13	14	3
Union Hill	6031	F	——	12.99	14.22	3.42
Lazaretto Dissolved Phosphate		G	——	14	15	——
Union Hill	6033	F	——	14.94	15.24	——
Lazaretto Dissolved Phosphate and Potash		G	——	10	11	2
Union Hill	6032	F	——	10.34	10.84	2.12
Lazaretto Extra Ammoniated Bone Phosphate		G	0.82	8	9	4
Union Hill	6034	F	1.01	8.05	9.63	3.94
Lazaretto High Grade Alkaline Dissolved Bone		G	——	10	11	8
Union Hill	6030	F	——	10.32	10.84	8.12
Michigan Carbon Works General Crop		G	0.82	8	9	4
Middleport	5918	F	0.94	9.24	10.20	3.72
Michigan Carbon Works Homestead Fertilizer		G	2.06	8	9	1.5
North Collins	5920	F	1.76	7.90	9.00	1.76
Michigan Carbon Works Homestead Potato and Tobacco Fertilizer		G	2.06	8	9	3
Middleport	5917	F	2.10	9.01	10.33	3.20
Michigan Carbon Works Red Line Phosphate with Potash		G	——	10	11	2
Fredonia	5934	F	——	11.19	11.67	1.63
Milsom's Buffalo Fertilizer		G	2.06	8	9	1.5
West Falls	5100	F	2.02	7.66	9.12	1.88

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
American Agricultural Chemical Co., New York, N. Y. (*continued*)						
Milsom's Buffalo Guano		G*	0.82	8	9	4
Adams	5156	F*	0.88	8.38	9.60	4.11
Milsom's Corn Fertilizer		G	2.47	9	10	2
Springbrook	5044	F	2.33	8.38	10.11	2.44
Milsom's Crown Phosphate		G	——	10	11	2
Adams	5164	F	——	10.04	11.48	2.29
Milsom's Eclipse Phosphate		G	——	10	11	8
Adams	5152	F	——	9.99	11.41	8.41
Milsom's Erie King Fertilizer		G	0.82	7	8	1
South Berne	5202	F	1.08	7.78	9.50	1.59
Milsom's Fancy Fruit Grower		G	0.82	9	10	7
Cazenovia	5842	F	1.08	9.58	10.52	7.26
Milsom's Harrow Brand Phosphate		G	2.47	6	7	10
Little York	6164	F	2.65	6.27	7.69	8.42
Milsom's Imperial Phosphate		G	——	12	13	5
Penn Yan	4917	F	——	12.78	13.84	4.44
Milsom's Medal Brand Manure		G	3.29	6	7	10
McGrawville	6352	F	3.37	6.75	7.65	10.18
Milsom's Old Pilot Phosphate		G	2.06	8	9	3
Adams	5151	F	2.04	8.32	10.23	3.24
Milsom's Old Pilot		G	2.06	8	9	3
Hartwick	5781	F	2.44	8.16	9.50	2.96
Milsom's Potato and Cabbage Manure		G	0.82	9	10	7
Springbrook	5045	F	0.98	8.86	10.14	6.63
Milsom's Potato and Truck Grower		G	1.65	8	9	10
Adams	5165	F	1.68	7.67	8.69	10.43

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
AMERICAN AGRICULTURAL CHEMICAL CO., NEW YORK, N. Y. (*continued*)						
Milsom's Potato and Truck Grower		G*	1.65	8	9	10
McGrawville	6351	F*	1.70	8.60	9.50	10.08
Milsom's Soil Enricher		G	1.65	8	9	4
Canandaigua	6005	F	1.59	8.57	9.95	3.96
Milsom's Vegetable Fertilizer		G	3.29	8	9	7
Springbrook	5901	F	3.34	8.31	9.37	6.71
Milsom's Wheat, Oats and Barley		G	0.82	8	9	2
McGrawville	6353	F	0.94	8.51	9.69	2.34
Muriate of Potash		G	——	——	——	49
Brockport	5353	F	——	——	——	50.34
Muriate of Potash		G	——	——	——	49
West Haverstraw	5477	F	——	——	——	48.44
Muriate of Potash		G	——	——	——	49
De Ruyter	6390	F	——	——	——	50.80
Nitrate of Soda		G	15	——	——	——
Cortland	4438	F	15.39	——	——	——
Nitrate of Soda		G	15	——	——	——
West Haverstraw	5476	F	15.12	——	——	——
Nitrate of Soda		G	15	——	——	——
Cooperstown	5552	F	15.23	——	——	——
North Western Challenge Fertilizer		G	1.03	8	9	2
Catskill	5694	F	1.06	8.05	9.69	2.44
North Western Complete Compound		G	0.82	8	9	4
Waterloo	4904	F	0.90	9.95	11.09	4.07
North Western Diamond Potash Mixture		G	1.65	8	9	10
East Aurora	5077	F	1.73	8.33	10.01	9.72
North Western Electric Phosphate		G	——	10	11	2
Hamlin	4546	F	——	10.66	11.22	2.32

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer: Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
American Agricultural Chemical Co., New York, N. Y. (*continued*)						
North Western Farmers' Standard		G*	1.23	6	7	5
Frewsburg	5097	F*	1.23	5.95	7.59	4.87
North Western Garden Manure		G	3.29	8	9	7
Orchard Park	5022	F	3.45	7.32	9.24	7.60
North Western High Grade Alkaline Phosphate		G	——	10	11	8
Malone	3773	F	——	10.47	11.57	8.42
North Western High Grade Alkaline Phosphate		G	——	10	11	8
Hamlin	4548	F	——	10.57	10.71	8.04
North Western Horse Shoe Brand		G	——	12	13	5
Batavia	5385	F	——	12.32	12.94	5.18
North Western Pride of the North		G	1.65	5	6	10
Rhinebeck	4829	F	2.09	6.29	7.33	10.44
North Western Pride of the North		G	1.65	5	6	10
Cazenovia	5839	F	1.29	6.08	7.46	10.96
North Western Pride of the North		G	1.65	5	6	10
Homer	6163	F	1.86	5.53	7.91	9.88
North Western Puritan Phosphate		G	0.82	9	10	7
Frewsburg	5098	F	1.00	9.53	11.03	6.98
North Western Red Line Fertilizer		G	2.47	8	9	6
Cazenovia	5838	F	2.66	7.96	8.86	7.82
North Western Shawnee Phosphate		G	1.65	8	9	4
Palmyra	5364	F	1.67	8.03	10.07	4.20
North Western Soluble Fertilizer		G	3.29	6	7	10
Chittenango Station	5816	F	3.33	6.03	7.57	9.71
North Western Success Phosphate		G	0.82	7	8	1
Croghan	3778	F	0.88	6.99	8.99	3.42

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER			
			Nitrogen	Phosphoric acid		Potash
				Available	Total	
AMERICAN AGRICULTURAL CHEMICAL CO., NEW YORK, N. Y. (*continued*)						
North Western XXX Alkaline Phosphate		G*	——	10	11	5
Elba	5388	F*	——	9.39	9.95	5.56
Pacific Nobsque Guano		G	1.03	8	9	2
Colden	5080	F	1.02	7.54	9.24	2.32
Packers' Union Animal Corn Fertilizer		G	2.47	9	10	2
Afton	5824	F	2.79	9.33	10.27	2.18
Packers' Union Banner Wheat Grower		G	——	10	11	2
Hudson Falls	5315	F	——	10.69	12.27	2.66
Packers' Union Gardener's Complete Manure		G	3.29	6	7	10
Afton	5823	F	3.16	6.52	7.84	9.82
Packers' Union Potato Manure		G	2.06	8	9	6
Afton	5825	F	2.19	8.30	9.39	5.30
Potato and Garden Manure		G	3.29	7	8	7
Little Neck	5458	F	3.47	7.67	9.05	7.22
Potato and Onion Special		G	1.65	10	11	6
Marion	4774	F	1.91	10.75	12.37	6.90
Pulverized Sheep Manure		G	2.06	——	1.25	1
Freeport	5411	F	2.17	1.27	1.53	5.40
Pure Unleached Canada Hardwood Ashes		G	——	——	——	2
New York	6102	F	——	——	——	3.36
Quinnipiac Ammoniated Dissolved Bone		G	1.65	8	9	2
Darien	5390	F	1.71	7.28	9.24	2.90
Quinnipiac B Fertilizer		G	0.82	8	9	4
Webster	6036	F	0.93	8.21	9.37	3.66

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid		Potash
				Available	Total	
American Agricultural Chemical Co., New York, N. Y. (*continued*)						
Quinnipiac Climax Phosphate		G*	1.03	8	9	2
Baldwinsville	6155	F*	1.00	8.27	9.37	2.66
Quinnipiac Market Garden Manure		G	3.29	8	9	7
Webster	6037	F	3.52	8.73	10.01	6.55
Quinnipiac Mohawk Fertilizer		G	0.82	7	8	1
Baldwinsville	6156	F	1.10	7.82	9.24	1.24
Quinnipiac Potato Phosphate		G	2.06	8	9	3
Schuyler Lake	5779	F	2.17	6.92	7.84	6.40
Read's Champion Phosphate		G	——	10	11	2
Wales Center	5047	F	——	10.02	10.52	2.14
Read's Corn, Wheat and Rye		G	1.65	8	9	4
Carthage	5180	F	1.64	8.46	9.76	4.20
Read's Farmers Friend Super Phosphate		G	2.06	8	9	3
Carthage	5176	F	1.97	8.34	9.82	3.26
Read's Farmers' Reliable		G	——	12	13	5
Sharon Springs	5242	F	——	13.32	14.16	5.16
Read's High Grade Farmers' Friend		G	3.29	6	7	10
Wolcott	6023	F	3.42	6.66	8.10	9.92
Read's Leader Fertilizer		G	0.82	7	8	1
Wales Center	5046	F	1.00	7.72	8.54	1.26
Read's Lion Crop Grower		G	1.23	6	7	5
Otego	5777	F	1.36	6.92	8.10	5.32
Read's Oriole Fertilizer		G	2.47	6	7	5
Lima	6043	F	2.05	7.35	8.40	4.56
Read's Pioneer Fertilizer		G	0.82	8	9	2
Wales Center	5048	F	1.14	7.63	9.37	2.02

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
AMERICAN AGRICULTURAL CHEMICAL CO., NEW YORK, N. Y. (*continued*)						
Read's Potash Compound		G*	1.65	8	9	10
Carthage	5177	F*	1.81	8.62	9.76	9.03
Read's Potato Manure		G	2.47	6	7	10
Clyde	4759	F	2.51	6.65	7.33	11.14
Read's Practical Potato Special		G	0.82	4	5	8
Carthage	5179	F	0.91	5.72	7.52	8.40
Read's Standard Super Phosphate		G	0.82	8	9	4
Carthage	5178	F	1.03	8.15	9.31	4.45
Read's 10 and 8		G	——	10	11	8
Perry	3198	F	——	10.58	11.92	8.24
Read's 10 and 8		G	——	10	11	8
Carthage	5706	F	——	11.21	12.37	7.74
Read's Truck Fertilizer		G	3.29	8	9	7
Lynbrook	5431	F	3.27	7.84	9.22	8.26
Read's Vegetable and Vine Fertilizer		G	2.06	8	9	6
Wolcott	6022	F	2.05	8.39	10.39	6.08
Reese's Crown Phosphate and Potash		G	——	11	12	2
East Bethany	6451	F	——	11.48	11.92	3.32
Reese's Elm Phosphate		G	——	14	15	——
Perry	6455	F	——	14.76	15.30	——
Reese's Potato Manure		G	0.82	9	10	7
Elma	5043	F	0.88	9.28	10.46	7.50
16% Acid Phosphate		G	——	16	17	——
De Ruyter	6389	F	——	15.98	16.84	——
Special Cabbage and Cauliflower Fertilizer		G	4.11	5	6	5
Wading River	5514	F	3.92	5.68	6.44	4.93
Special Potash Mixture		G	0.82	9	10	7
Marion	5366	F	1.08	9.78	10.52	7.34

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer: Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
American Agricultural Chemical Co., New York, N. Y. (*continued*)						
Superior Alkaline Bone		G*	——	10	11	5
East Henrietta	6018	F*	——	9.87	10.46	5.04
12% Acid Phosphate		G	——	12	13	——
South Berne	5201	F	——	12.10	13.84	——
Wheeler's Bermuda Onion Grower		G	0.82	9	10	7
Hartwick	5782	F	1.09	8.97	9.95	6.22
Wheeler's Corn Fertilizer		G	1.65	8	9	2
Sherburne	5802	F	1.67	8.88	10.14	1.96
Wheeler's Fruit and Grain Grower		G	——	10	11	8
Hudson Falls	5316	F	——	10.46	11.35	8.58
Wheeler's High Grade Phosphate and Potash		G	——	12	13	5
Delanson	5134	F	——	13.11	14.09	5.10
Wheeler's Peerless Acid Phosphate		G	——	14	15	——
Delanson	5132	F	——	15.13	16.13	——
Wheeler's Potato Manure		G	2.06	8	9	3
Hartwick	5783	F	1.60	9.38	10.20	3.90
Wheeler's Royal Wheat Grower		G	0.82	8	9	2
Conewango	5927	F	0.92	8.22	8.73	2.28
Wheeler's Superior Truck		G	3.29	8	9	7
Hicksville	5439	F	3.41	8.27	9.63	7.32
Wheeler's Wheat and Clover		G	——	11	12	2
Fort Ann	5319	F	——	11.16	12.34	2.56
Williams & Clark's Americus Fertilizer		G	1.65	8	9	10
Berlin	5679	F	1.70	8.05	8.93	9.76
Williams & Clark's Aroostook Potato Phosphate		G	3.29	6	7	10
Eagle	6462	F	2.63	6.03	7.65	9.16

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
AMERICAN AGRICULTURAL CHEMICAL CO., NEW YORK, N. Y. (*continued*)						
Williams and Clark's Root Manure		G*	0.82	9	10	7
South Plymouth	6316	F*	0.87	8.59	9.60	6.51
Williams & Clark's Elk Brand		G	0.82	8	9	4
South Plymouth	6313	F	0.84	8.38	9.24	4.42
Williams & Clark's Good Grower		G	1.23	6	7	5
Johnstown	5593	F	1.33	6.43	7.91	4.94
Williams & Clark's Great Planet Manure		G	3.29	8	9	7
Berlin	5676	F	3.35	8.02	9.24	6.84
Williams & Clark's Matchless Fertilizer		G	1.65	8	9	2
Berlin	5678	F	1.59	8.53	10.07	2.34
Williams & Clark's Meadow Queen Fertilizer		G	2.47	9	10	2
White Plains	5617	F	2.65	10.17	11.67	1.96
Williams & Clark's Meadow Queen Fertilizer		G	2.47	9	10	2
Hamburg	5935	F	2.32	9.26	10.14	3.14
Williams & Clark's Panther Phosphate		G	1.65	5	6	10
South Plymouth	6315	F	1.67	6.11	7.27	9.98
Williams & Clark's Potash and Fish		G	2.47	4	5	4
Bridgehampton	5529	F	2.48	4.43	6.07	4.76
Williams & Clark's Prolific Fertilizer		G	0.82	7	8	1
Berlin	5675	F	0.85	7.94	9.50	1.46
Williams & Clark's Royal Phosphate		G	1.03	8	9	2
South Plymouth	6314	F	0.96	8.61	9.95	2.36
Williams & Clark's Triumph Phosphate		G	——	10	11	2
Berlin	5677	F	——	10.64	11.60	2.76
Zell's Economizer Phosphate		G	0.82	8	9	2
Falconer	5099	F	0.99	8.18	9.44	3.17

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer: Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
American Agricultural Chemical Co., New York, N. Y. (*concluded*)						
Zell's Electric Phosphate		G*	——	10	11	2
Prattsburg	6549	F*	——	10.72	11.16	3.16
Zell's Fruit Tree Invigorator		G	——	10	11	8
Interlaken	6528	F	——	10.11	10.71	7.91
Zell's General Crop Fertilizer		G	0.82	8	9	4
Marion	4773	F	0.89	9.73	10.93	4.06
Zell's High Grade Bone and Potash		G	——	12	13	5
Marion	4772	F	——	12.21	13.05	4.77
Zell's High Grade Wheat and Corn Manure		G	1.65	10	11	4
Marion	4771	F	2.06	10.74	12.56	5.60
Zell's Special Potato and Cabbage Manure		G	0.82	9	10	7
Marion	4776	F	0.82	10.61	11.41	6.12
American Fertilizing Co., Baltimore, Md.						
American Champion Grain Grower		G	0.82	8	9	4
Springville	5034	F	0.99	8.40	10.09	4.90
American Eagle Crop Grower		G	1.65	8	9	2
Sinclairville	5931	F	1.67	9.18	10.78	2.36
American Excelsior Guano		G	1.65	8	9	5
Pine Bush	5685	F	1.77	8.62	9.84	5.38
American Formula Wheat and Corn		G	——	10	11	5
Springville	5038	F	——	10.28	11.60	5.08
American Potato and Vegetable Compound		G	3.29	6	7	10
Springville	5033	F	3.63	6.10	7.52	11.72
American Prize Truck Guano		G	1.65	8	9	10
Avoca	4931	F	2.04	8.76	9.82	10.08
American Standard Crop Compound		G	——	10	11	8
Attica	3190	F	——	9.81	11.03	9.02

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER			
			Nitrogen	Phosphoric acid Available	Phosphoric acid Total	Potash
AMERICAN FERTILIZING CO., BALTIMORE, MD. (*concluded*)						
Ammoniated Bone Compound		G*	0.82	8	9	2
Springville	5037	F*	0.92	8.15	9.26	2.10
Bob White Manure Compound		G	1.23	9	10	4
Attica	3189	F	1.52	9.42	10.68	4.90
Dissolved Bone and Potash		G	——	10	11	2
Sinclairville	5932	F	——	10.30	11.86	2.36
Double Extra Bone and Potash		G	——	12	13	5
Springville	5036	F	——	12.64	14.28	4.85
High Grade Acid Phosphate		G	——	14	15	——
Batavia	5381	F	——	15.35	16.71	——
Muriate of Potash		G	——	——	——	48
Pine Bush	5687	F	——	——	——	50.16
Nitrate of Soda		G	14.82	——	——	——
Pine Bush	5688	F	14.82	——	——	——
Sulphate of Potash		G	——	——	——	48
De Ruyter	5831	F	——	——	——	50.12
10% Tankage		G	8.23	——	——	——
South Dayton	5945	F	7.98	——	——	——
ARMOUR FERTILIZER WORKS, BALTIMORE, MD.						
Armour's All Soluble		G	2.88	8	8.50	4
Cincinnatus	6365	F	2.84	8.29	9.63	4.52
Armour's Ammoniated Bone with Potash		G	2.47	6	6.50	2
Florida	5682	F	2.43	6.40	7.20	2.24
Armour's Banner Brand		G	——	10	10.50	8
Altamont	5203	F	——	9.61	10.01	7.87
Armour's Bone, Blood and Potash		G	4.11	8	8.50	7
Delhi	3639	F	3.83	8.11	9.31	7.28

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer: Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
Armour Fertilizer Works, Baltimore, Md. (*continued*)						
Armour's Bone Meal		G*	2.47	——	22	——
Hempstead	5462	F*	2.10	——	27.16	——
Armour's Cauliflower, Celery and Potato Mixture		G	4.93	8	8.50	5
Aquebogue	5491	F	5.22	7.73	8.61	4.61
Armour's Conn. Valley Tobacco Grower Fertilizer		G	4.52	4	4.50	5.50
Cato	6511	F	4.56	4.77	5.35	6.34
Armour's Corn and Wheat Fertilizer		G	1.65	8	8.50	5
Richfield Springs	5555	F	1.50	9.19	9.95	5.32
Armour's Crop Grower		G	0.82	8	8.50	2
Cortland	6152	F	1.15	8.36	8.86	4.25
Armour's Dried Blood Fertilizer		G	13.16	——	——	——
White Plains	5621	F	12.74	——	——	——
Armour's Fruit and Root Crop Special Fertilizer		G	1.65	8	8.50	5
Adams	5153	F	1.78	8.03	9.03	5.12
Armour's Grain Grower		G	1.65	8	8.50	2
Altamont	5206	F	1.73	7.86	9.76	2.96
Armour's High Grade Potato		G	1.65	8	8.50	10
Altamont	5205	F	1.42	8.35	9.37	8.56
Armour's High Grade Potato		G	1.65	8	8.50	10
Barneveld	5579	F	1.61	7.81	8.73	10.28
Armour's Long Island Trucker		G	3.29	5	5.50	6
Marathon	6383	F	3.27	5.82	6.44	6.06
Armour's Manure Substitute		G	3.29	6	6.50	4
Middletown	5605	F	3.07	5.71	6.80	4.12
Armour's Manure Substitute		G	3.29	6	6.50	4
Liberty	6409	F	2.73	6.97	8.01	3.82
Armour's Phosphate and Potash		G	——	12	12.50	5
Adams	5155	F	——	12.42	12.70	5.18

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
ARMOUR FERTILIZER WORKS, BALTIMORE, MD. (*continued*)						
Armour's Phosphate and Potash No. 1		G*	——	10	10.50	2
Delhi	3642	F*	——	9.37	9.85	2.20
Armour's Potato and Grain Special Fertilizer		G	0.82	9	9.50	7
LeRoy	5380	F	0.85	8.78	9.24	7.32
Armour's Potato Special Fertilizer		G	2.05	6	6.50	6
Cohocton	4927	F	1.98	5.81	6.31	6 80
Armour's Raw Bone Meal		G	3.70	——	21.50	——
North Collins	5065	F	3.90	——	24.62	——
Armour's Special Potato Grower		G	3.29	8	8.50	7
Hempstead	5461	F	3.10	8.38	9.28	7.52
Armour's Star Phosphate Fertilizer		G	——	14	14.50	——
Rochester	4544	F	——	13.76	13.86	——
Armour's Star Phosphate		G	——	1	14.50	——
Poughkeepsie	4810	F	——	14.69	15.59	——
Armour's Star Phosphate		G	——	14	14.50	——
Kings Park	5413	F	——	15.03	15.04	——
Armour's Star Phosphate		G	——	14	14.50	——
Central Islip	5466	F	——	14.14	14.86	——
Armour's Star Phosphate		G	——	14	14.50	——
Middletown	5601	F	——	14.99	15	——
Armour's Star Phosphate		G	——	14	14.50	——
Yorktown	5471	F	——	14.15	15.05	——
Armour's Star Phosphate		G	——	14	14.50	——
Richfield Springs	5557	F	——	14.57	15.69	——
Armour's Truckers Special Fertilizer		G	3.29	6	6.50	10
Cortland	6341	F	3.22	6.16	6.88	10.40
Armour's Wheat & Clover		G	——	10	10.50	5
Boonville	5572	F	——	10.09	10.72	4.85

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
				Phosphoric acid		
			Nitrogen	Available	Total	Potash
Armour Fertilizer Works, Baltimore, Md. (*concluded*)						
Armour's Wheat, Corn and Oat Special		G*	0.82	7	7.50	1
McGraw	6450	F*	1.22	7.25	7.59	1.36
Armour's York State Special		G	0.82	8	8.50	4
Altamont	5204	F	0.91	8.18	8.86	4.06
Armour's York State Special		G	0.82	8	8.50	4
Boonville	5573	F	1.02	8.48	9.24	4.42
Basic Slag		G	——	——	17†	——
Cuba	5961	F	——	——	17.81	——
Genuine German Kainit		G	——	——	——	12
Aquebogue	5493	F	——	——	——	13.72
Ground Tankage		G	4.93	——	13.74	——
Aquebogue	5492	F	4.95	——	13.32	——
Ground Tankage		G	7.41	——	6.60	——
Oneida	6175	F	7.03	——	10.34	——
Muriate of Potash		G	——	——	——	48
Collins	5051	F	——	——	——	48.60
Muriate of Potash		G	——	——	——	48
Middletown	5602	F	——	——	——	45.84
Nitrate of Soda		G	14.81	——	——	——
Utica	4238	F	15.05	——	——	——
Nitrate of Soda		G	14.81	——	——	——
Rochester	4543	F	14.92	——	——	——
Nitrate of Soda		G	14.81	——	——	——
Collins	5052	F	15.06	——	——	——
Nitrate of Soda		G	14.81	——	——	——
Kings Park	5414	F	14.88	——	——	——
Nitrate of Soda		G	14.81	——	——	——
Yorktown	5473	F	14.86	——	——	——

* These letters indicate, respectively, Guaranteed and Found.
† No official method for determining available P_2O_5 in this sample.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid — Available	Phosphoric acid — Total	Potash
ATLANTIC FERTILIZER WORKS, BALTIMORE, MD.						
Atlantic Arrow Brand Special		G*	0.82	8	——	4
Holmesville	5858	F*	0.95	7.76	8.10	3.94
Atlantic G. G. G. Golden Grain Grower		G	1.65	9	——	4
Greene	5820	F	1.68	9.71	10.65	3.83
Atlantic Royal Potato and Tomato Manure		G	1.65	7	——	5
Bainbridge	5827	F	1.51	7.16	7.60	4.83
Atlantic Special Phosphate and Potash		G	——	10	——	8
Greene	5821	F	——	10.29	10.95	7.54
Atlantic Standard Compound		G	1.65	8	——	2
Hamden	3636	F	1.66	7.95	8.29	2.06
Atlantic X X Special Compound for Potatoes		G	1.65	8	——	10
Hamden	3634	F	1.62	7.75	8.25	10.04
ATLANTIC PACKING CO., SYRACUSE, N. Y.						
Atlantic Corn and Wheat Brand		G	1.64	8	9	4
Canastota	5881	F	1.73	8.42	9.07	4.34
Atlantic Grass and Grain Brand for Oats, Buckwheat and Seeding Down		G	0.82	7	8	2
Boonville	5588	F	1.03	6.99	7.65	2.38
Atlantic Ground Bone		G	2.45	——	23	——
Oneida	5812	F	2.76	——	25.38	——
Atlantic Hop and Potato Brand		G	0.82	8	9	4
Boonville	5587	F	1.12	7.92	8.54	3.96
Atlantic Reliable Brand		G	1.24	8	9	4
Boonville	5589	F	1.32	8.20	8.86	4.32
Atlantic Special for Celery, Cabbage and Potatoes		G	1.24	7	8	9
Boonville	5586	F	1.46	7.40	8.10	9.06

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
Baugh & Sons Co., Philadelphia, Pa.						
Baugh's Animal Base and Potash Compound for all Crops		G*	1.65	8	——	2
Waverly	6162	F*	1.75	8.48	9.56	2.18
Baugh's Balanced Plant Food		G	1.65	10.50	——	7
Walton	6413	F	1.80	11.56	13.05	7.44
Baugh's Commercial Super-Phosphate for General Use		G	1.65	8	——	10
Pierrepont Manor	5196	F	1.26	8.77	9.87	10.52
Baugh's Commercial Super-Phosphate for General Use		G	1.65	8	——	10
Poughkeepsie	4808	F	1.34	6.21	6.97	11.07
Baugh's Complete Animal Base Fertilizer		G	1.65	8	——	5
Binghamton	6305	F	1.77	8.52	9.56	5.48
Baugh's Complete Animal Base Fertilizer		G	1.65	8	——	5
Port Byron	6517	F	1.82	8.70	9.50	5.08
Baugh's Complete Animal Base Fertilizer		G	1.65	8	——	5
Lodi	6536	F	1.82	8.57	9.63	5.56
Baugh's Complete Animal Base Fertilizer		G	1.65	8	——	5
Burdette	6554	F	1.71	8.80	9.76	5.06
Baugh's 8 and 5 Special Alkaline Super-Phosphate		G	——	8	——	5
Chenango Bridge	5864	F	——	8.76	9.50	5.08
Baugh's Energetic Super Phosphate		G	0.82	8	——	8
Ellenville	5690	F	1.22	9.37	11.35	7.53
Baugh's Excelsior Guano		G	0.82	8	——	4
Binghamton	6307	F	1.15	8.22	9.31	4.96
Baugh's Excelsior Guano		G	0.82	8	——	4
Crocketts	6510	F	0.90	8.40	9.18	4.64

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
BAUGH & SONS CO., PHILADELPHIA, PA. (*continued*)						
Baugh's Fine Ground Bone		G*	2.47	——	16.49	——
Binghamton	6308	F*	2.60	——	16.26	——
Baugh's Fruit and Berry Guano		G	2.47	8	——	10
Bath	6550	F	2.52	8.41	9.12	10.52
Baugh's General Crop Grower		G	0.82	8	——	1
Wellsburg	4790	F	1.28	8.53	9.47	3.18
Baugh's General Crop Grower		G	0.82	8	——	1
Warwick	5683	F	1.00	8.91	11.35	1.30
Baugh's High Grade Acid Phosphate		G	——	14	——	——
Utica	4235	F	——	15.13	15.69	——
Baugh's High Grade Acid Phosphate		G	——	14	——	——
Burdette	6553	F	——	17.27	17.67	——
Baugh's High Grade Potato Grower		G	3.30	8	——	10
Schenectady	5209	F	3.42	8.78	10.46	10.03
Baugh's High Grade Potato Grower		G	3.30	8	——	10
Sennett	6518	F	3.12	9.03	9.56	8.47
Baugh's New Process 10% Guano		G	8.23	5	——	2.50
Hoosick Falls	5681	F	7.34	8.86	9.76	3.16
Baugh's Peninsula Grain Producer		G	0.82	9	——	3
Tunnell	5885	F	1.21	9.41	10.55	5.53
Baugh's Phosphate and Potash		G	——	10	——	8
Chenango Bridge	5866	F	——	10.57	11.09	7.30
Baugh's Potato and Truck Special for all Truck Crops		G	2.88	7	——	7
Pierrepont Manor	5195	F	2.93	8.11	8.93	7.52
Baugh's Pure Bone and Muriate of Potash Mixture		G	2.47	——	15	5
Catskill	5693	F	2.88	——	15.14	5.60
Baugh's Pure Bone and Muriate of Potash Mixture		G	2.47	——	15	5
Chenango Bridge	5865	F	2.80	——	15.37	7.64

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
Baugh & Sons Co., Philadelphia, Pa. (*concluded*)						
Baugh's Pure Bone and Muriate of Potash Mixture		G*	2.47	——	15	5
Moravia	6503	F*	2.60	——	17.60	4.37
Baugh's Raw Bone Meal		G	3.70	——	21.50	——
Schenectady	5207	F	3.89	——	21.59	——
Baugh's 16 % Acid Phosphate		G	——	16	——	——
Binghamton	6306	F	——	17.21	17.47	——
Baugh's Soluble Alkaline Superphosphate		G	——	10	——	2
Taylor	6374	F	——	10.81	11.53	2.66
Baugh's Soluble Top Dresser for all Crops		G	8.23	——	——	3
Pierrepont Manor	5703	F	7.93	——	——	4.70
Baugh's Special Potato Manure		G	1.65	5	——	10
Binghamton	6304	F	2.06	5.79	6.37	9.98
Baugh's Special Potato Manure		G	1.65	5	——	10
Sennett	6519	F	1.82	5.68	6.76	10.70
Baugh's 12 and 5 Phosphate and Potash		G	——	12	——	5
Skaneateles	6173	F	——	12.15	13.05	5.10
Baugh's 12% Acid Phosphate		G	——	12	——	——
Wellsburg	4791	F	——	16.16	16.52	——
Fine Ground Phosphate Rock		G	——	——	30	——
Creedmoor	5447	F	——	——	31.38	——
Genuine German Kainit		G	——	——	——	12.40
Chittenango Station	5813	F	——	——	——	12.84
Genuine German Kainit		G	——	——	——	12.40
Waverly	6161	F	——	——	——	12.44
Muriate of Potash		G	——	——	——	50
Ithaca	6170	F	——	——	——	45.14
Nitrate of Soda		G	15.23	——	——	——
Binghamton	6303	F	15.58	——	——	——

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid Available	Phosphoric acid Total	Potash
BERKSHIRE FERTILIZER CO., BRIDGEPORT, CONN.						
Berkshire Complete Fertilizer		G*	2.50	8	9	6
Orient	5522	F*	2.77	8.39	8.67	6.98
Cyanamid Mixture		G	4.10	8	——	6
Medford	5519	F	4.31	7.72	8.22	6.94
BOWKER FERTILIZER CO., NEW YORK, N. Y.						
Bowker's Ammoniated Dissolved Bone		G	1.65	8	9	2
North Collins	5064	F	1.77	7.85	9.70	2.06
Bowker's B. B. & P. Compound		G	4.11	7	8	7
Riverhead	5498	F	4.13	7.24	8.48	7.12
Bowker's Best Grain Fertilizer		G	1.23	10	11	6
Bowmansville	5903	F	1.42	9.72	11.80	6.48
Bowker's Corn and Grain Grower		G	0.82	8	9	4
Syracuse	6318	F	0.97	8.88	9.82	4.22
Bowker's Corn and Wheat Guano		G	1.65	8	9	4
Adams	5173	F	2.07	7.84	10.39	4.36
Bowker's Dissolved Phosphate		G	——	11	12	——
Schoharie	5658	F	——	11.65	12.43	——
Bowker's Early Potato Manure		G	3.29	7	8	7
Hicksville	5422	F	3.39	8.11	9.05	7.58
Bowker's Empire State Phosphate and Potash		G	——	8	9	3
Warsaw	3192	F	——	7.82	8.32	3.24
Bowker's Farm and Garden Phosphate		G	1.65	8	9	2
Syracuse	6323	F	1.99	8.54	9.76	2.08
Bowker's Fresh Ground Bone		G	2.47	——	22.88	——
Warsaw	3193	F	2.55	——	22.96	——
Bowker's Golden Harvest Fertilizer		G	——	12	13	5
Cherry Valley	5219	F	——	12.13	13.04	5.08

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer: Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
BOWKER FERTILIZER CO., NEW YORK, N. Y. (*continued*)						
Bowker's Grain and Grass Fertilizer		G*	2.47	8	9	4
Fly Creek	5598	F*	2.51	7.84	9.77	4.28
Bowker's Hill and Drill Phosphate		G	2.47	9	10	2
Syracuse	6319	F	2.63	9.47	10.97	2.30
Bowker's Hop and Potato Phosphate with Extra Potash		G	0.82	8	9	5
Cherry Valley	5217	F	0.95	8.54	9.50	4.88
Bowker's Lawn and Garden Dressing		G	3.29	4	5	5
Binghamton	5822	F	3.73	4.33	5.17	5.46
Bowker's Market Garden Fertilizer		G	2.47	6	7	10
Syracuse	6322	F	2.67	6.85	7.71	10.46
Bowker's Potash Fertilizer		G	0.82	6	7	2
Buffalo	5019	F	0.99	6.56	7.78	2.42
Bowker's Potash or Staple Phosphate		G	0.82	8	9	3
Camden	5754	F	0.97	8.54	9.56	3.28
Bowker's Potash or Staple Phosphate		G	0.82	8	9	3
Falconer	5928	F	1.00	8.01	8.99	4.10
Bowker's Potato and Vegetable Fertilizer		G	2.47	8	9	4
Patchogue	5538	F	2.57	8.12	9.50	4
Bowker's Six per Cent Potato Fertilizer		G	0.82	6	7	6
Carthage	5704	F	0.94	6.33	7.61	6.62
Bowker's Soluble Phosphate		G	——	14	15	——
Adams	5174	F	——	14.36	14.86	——
Bowker's Special Crop Grower		G	1.65	8	9	10
Clyde	4765	F	1.71	8.52	9.82	10.72
Bowker's Special Crop Grower		G	1.65	8	9	10
Syracuse	6324	F	1.78	8.62	9.82	10.28

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
BOWKER FERTILIZER CO., NEW YORK, N. Y. (*concluded*)						
Bowker's Super Phosphate with Potash		G*	——	10	11	2
Newark Valley	6355	F*	——	10.34	10.84	2.66
Bowker's Sure Crop Phosphate		G	0.82	9	10	2
Syracuse	6325	F	0.83	9.41	10.27	2.74
Bowker's Ten and Eight		G	——	10	11	8
Syracuse	6320	F	——	10.45	11.03	8.04
Bowker's Ten Per Cent Manure		G	0.82	5	6	10
Syracuse	6321	F	0.91	5.98	7.52	10.04
Genuine German Kainit		G	——	——	——	12
Mattituck	5489	F	——	——	——	13.54
Ground Tankage		G	7.40	——	9.15	——
Mumford	6042	F	7.41	——	10.07	——
Nitrate of Soda		G	15.	——	——	——
Valley Stream	5434	F	15.58	——	——	——
Stockbridge Special Complete Manure for Corn and all Grain Crops		G	3.29	10	11	7
Fly Creek	5595	F	3.41	10.07	11.29	7.64
Stockbridge Special Complete Manure for Potatoes and Vegetables		G	3.29	6	7	10
Syracuse	6326	F	3.35	6.72	7.52	10.58
Stockbridge Special Complete Manure for Seeding Down, Permanent Dressing and Legumes		G	2.47	10	11	8
Syracuse	6328	F	2.61	10.52	11.54	9.14
Stockbridge Special Complete Manure for Top Dressing and for Forcing		G	4.94	4	5	6
Syracuse	6327	F	4.97	4.74	5.74	6.36

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer: Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
BRADLEY & GREEN FERTILIZER CO., PHILADELPHIA, PA.						
Market Garden		G*	3.25	8	——	6
Queens	5450	F*	3.55	8.42	9.56	6.62
Standard Bone Phosphate for Corn, Wheat and Peas		G	2	8	——	3
Queens	5451	F	2.17	8.72	9.76	3.58
BUFFALO FERTILIZER WORKS, BUFFALO, N. Y.						
Dried Blood		G	9.84	——	——	——
Poughkeepsie	4809	F	10.32	——	——	——
BUTTS, J. P., ONEONTA, N. Y.						
Hustler		G	0.82	8	9	4
Oneonta	5759	F	1.00	9.11	10.33	4.20
Potato Manure No. 1		G	2.47	8	9	7
Oneonta	5758	F	2.75	8.69	9.69	7.22
Standard No. 1		G	1.23	8	9	2.50
Oneonta	5760	F	1.50	8.56	10.20	2.80
CASE & CO., A. H., BUFFALO, N. Y.						
Excelsior Brand Pulverized Sheep Manure		G	1	0.87	——	1
Elma	5042	F	2.30	2.49	2.61	1.21
CHITTENDEN CO., THE E. D., BRIDGEPORT, CONN.						
Chittenden's High Grade Potato		G	4.10	8	10	7
Calverton	5509	F	3.75	9.28	9.44	7.30
Chittenden's Potato and Grain		G	3.30	8	9	6
Hicksville	5402	F	3.33	9.93	10.07	6.36
Chittenden's Potato Special		G	3.30	8	9	7
Jericho	5403	F	3.22	8.94	10.20	7.68
Chittenden's Special for Corn, Cabbage and Cauliflower		G	4.95	8	9	5
Riverhead	5490	F	4.98	8.13	8.93	5.08

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
				Phosphoric acid		
			Nitrogen	Available	Total	Potash
CLARK & SON, O. W., BUFFALO, N. Y.						
Clark's Velvet Lawn Fertilizer		G*	2	5	——	3
Buffalo	5041	F*	2.80	8.40	9.24	3.96
Plant Food		G	3.50	7	——	6
Buffalo	5040	F	4.16	8.41	9.05	7.24
CLARK-BAYLIS CO., THE, MILFORD, CONN.						
Corn and Cabbage Special Manure		G	4.93	6	——	6
Hicksville	5419	F	4.97	7.46	7.74	6.76
CLAY & SON, STRATFORD, LONDON						
Clay's Fertilizer		G	4	1.15	7.20	0.10
New York	6104	F	4.63	2.39	7.03	0.12
COE-MORTIMER CO., THE, NEW YORK, N. Y.						
E. Frank Coe's Alkaline Bone and Potash		G	——	13	14	3
Jefferson	5246	F	——	13.35	13.65	2.92
E. Frank Coe's Celebrated Special Potato Fertilizer		G	1.65	8	9	4
Newark	4775	F	1.63	9.14	10.80	4.30
E. Frank Coe's Columbian Corn and Potato Fertilizer		G	1.23	8.50	9.50	2.5
North Collins	5066	F	1.32	8.55	10.33	2.6
E. Frank Coe's Double Strength Potato Manure		G	3.70	7	8	10
Cortland	6337	F	3.75	8.50	9.44	10.14
E. Frank Coe's Economical Potato Manure		G	0.82	4	5	8
Cherry Valley	5226	F	0.94	4.44	5.74	8.42
E. Frank Coe's Empire State Brand		G	1.23	9	10	6
Cherry Valley	5228	F	1.29	9.75	11.03	6.34
E. Frank Coe's Excelsior Potato Fertilizer		G	2.47	7	8	8
Deposit	5851	F	2.49	7.84	9.44	8

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer: Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
Coe-Mortimer Co., The, New York, N. Y. (*continued*)						
E. Frank Coe's Extra Special Potato Fertilizer and Fruit Grower		G*	1.65	8	9	10
Tully	6346	F*	1.74	8.42	10.20	9.96
E. Frank Coe's Famous Prize Brand Grain and Grass Fertilizer		G	——	10	11	2
Fort Ann	5320	F	——	9.82	12.12	2.24
E. Frank Coe's Gold Brand Excelsior Guano		G	2.47	8	9	6
Earlville	5810	F	2.37	8.17	10.33	5.90
E. Frank Coe's Golden Harvest Fertilizer		G	——	10	11	8
Cherry Valley	5227	F	——	10.51	11.41	7.94
E. Frank Coe's Grain and Vegetable Grower		G	0.82	8	9	7
Tully	6347	F	1.01	8.73	10.27	6.86
E. Frank Coe's High Grade Ammoniated Superphosphate		G	1.85	8	9	3
Holcomb	6013	F	1.99	8.51	10.07	3.16
E. Frank Coe's High Grade Dissolved Phosphate and Potash		G	——	8	9	5
Brockport	5362	F	——	8.24	9.38	5.14
E. Frank Coe's High Grade Soluble Phosphate		G	——	14	15	——
Jamison Road	5049	F	——	14.13	15.11	——
E. Frank Coe's New Englander Special Fertilizer		G	0.82	8	9	3
Earlville	5811	F	1.38	8.21	9.79	3.36
E. Frank Coe's Red Brand Excelsior Guano for Market Gardening		G	3.29	8	9	7
Cortland	6336	F	3.21	8.88	10.14	6.84
E. Frank Coe's Top Dressing Manure		G	7.41	6	7	3
Earlville	5809	F	6.74	6.74	7.84	3.58

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER			
			Nitrogen	Phosphoric acid Available	Phosphoric acid Total	Potash
COE-MORTIMER CO., THE, NEW YORK, N. Y. (*concluded*)						
E. Frank Coe's 12 % Superphosphate		G*	——	12	13	——
Cherry Valley	5224	F*	——	12.71	14.35	——
E. Frank Coe's Western New Yorker		G	0.82	8	9	4
Cherry Valley	5225	F	1.09	8.40	10.46	4.60
E. Frank Coe's XXV Ammoniated Phosphate		G	0.82	8	9	2
Batavia	5386	F	0.97	8.13	9.63	2.46
Nitrate of Soda		G	15	——	——	——
Hornell	4534	F	15.20	——	——	——
Sulphate of Potash		G	——	——	——	48
Hornell	4535	F	——	——	——	49.12
Thomas Phosphate Powder (Basic Slag Phosphate)		G	——	†15	17	——
Hornell	4536	F	——	——	17.28	——
Thomas Phosphate Powder (Basic Slag Phosphate)		G	——	†15	17	——
Colden	5079	F	——	——	17.12	——
COLUMBIA GUANO CO., BALTIMORE, MD.						
Columbia 14% Acid Phosphate		G	——	14	14.50	——
Glens Falls	5309	F	——	14.98	15.60	——
Columbia General Crop Manure		G	0.82	8	8.50	4
Glens Falls	5310	F	0.87	8.30	9.18	4.16
Columbia Grain Special Fertilizer		G	0.82	8	8.50	2
South Alabama	5387	F	0.90	8.55	9.33	1.94
Columbia Premium Phosphate and Potash		G	——	10	10.50	8
Lodi	6535	F	——	10.49	10.97	7.82
Columbia Special Potato Formula		G	1.65	8	8.50	10
Lodi	6534	F	1.74	8.35	9.31	10.28
Columbia Special Potato Guano		G	1.65	5	5.50	10
Glens Falls	5311	F	1.78	5.92	6.30	9.85

* These letters indicate, respectively, Guaranteed and Found.
† No official method for determining available P_2O_5 in this sample.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid, Available	Phosphoric acid, Total	Potash
COLUMBIA GUANO CO., BALTIMORE, MD. (*concluded*)						
Muriate of Potash		G*	——	——	——	49
Glens Falls	5312	F*	——	——	——	49.12
Nitrate of Soda		G	15	——	——	——
Glens Falls	5322	F	15.20	——	——	——
CONSUMERS FERTILIZER CO., NEW YORK, N. Y.						
Early Crop Odorless Fertilizer		G	3.28	8	9	7
Albany	4954	F	3.27	8.18	9.24	12.47
Raw Bone Meal		G	3.70	——	22	——
Albany	4955	F	4.02	——	22.18	——
COOPER'S GLUE FACTORY, PETER, NEW YORK, N. Y.						
Peter Cooper's Pure Bone Dust		G	2.05	——	22.88	——
New Rochelle	5624	F	2.02	——	26.66	——
DANIELS, FRED, HOUGHTON, N. Y.						
Daniels Commonsense Grain and Grass Grower		G	——	14	15	——
Machias	5958	F	——	14.32	14.86	——
DAY, MRS. R. WHITE, ARLINGTON, N. Y.						
Pure Bone and Meat Fertilizer		G	3.54	——	21.24	——
Arlington	4807	F	5.06	——	14.72	——
ENTERPRISE GUANO CO., BALTIMORE, MD.						
Bean and Cabbage Mixture		G	0.82	7	——	9
Watertown	5198	F	0.95	7.33	8.47	8.21
Complete Guano		G	0.82	8	——	2
Truxton	6168	F	0.83	8.90	10.20	2.10
Complete Manure for All Crops		G	1.65	8	——	5
Watertown	5701	F	1.73	8.56	9.50	5.40
Enterprise Corn and Wheat Compound		G	1.65	8	——	2
Truxton	6166	F	1.71	8.79	9.95	1.75

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER			
			Nitrogen	Phosphoric acid Available-	Phosphoric acid Total	Potash
ENTERPRISE GUANO CO., BALTIMORE, MD. (*concluded*)						
Enterprise 14% Acid Phosphate		G*	——	14	——	——
East Berne	5110	F*	——	15.52	15.62	——
Enterprise General Crop Grower		G	0.42	7	——	2
East Berne	5112	F	0.47	9.51	10.33	2.60
Enterprise Phosphate and Potash		G	——	10	——	8
Truxton	6167	F	——	10.44	10.78	7.67
Enterprise Special Trucker		G	2.47	6	——	10
New Berlin	5875	F	2.86	6.70	7.41	12.10
Enterprise Special Trucker		G	2.47	6	——	10
Weedsport	6516	F	2.67	6.24	7.84	9.98
Grain and Grass Compound		G	——	10	——	2
Watertown	5702	F	——	10.13	10.39	1.84
Ideal Grain Grower		G	0.82	8	——	4
Sharon Springs	5215	F	0.90	9.10	9.88	4.40
Muriate of Potash		G	——	——	——	50
Canandaigua	5398	F	——	——	——	51.14
Nitrate of Soda		G	15.23	——	——	——
Canandaigua	5399	F	14.96	——	——	——
Vegetable and Potato Guano		G	1.65	8	——	10
Watertown	5200	F	1.66	8.68	10.14	10.54
FEDERAL CHEMICAL CO., INC., LOUISVILLE, KY.						
Daybreak Tennessee Brown Phosphate Rock		G	——	——	29.75	——
Greene	5884	F	——	——	29.68	——
FERTILIZER MATERIALS SUPPLY CO., THE, NEW YORK, N. Y.						
Acid Phosphate		G	——	14	——	——
Willard	4784	F	——	14.15	14.99	——
Acid Phosphate		G	——	14	——	——
Ogdensburg	5253	F	——	13.19	14.03	——

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		Pounds in 100 Pounds of Fertilizer: Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
FERTILIZER MATERIALS SUPPLY CO., THE, NEW YORK, N. Y. (*concluded*)						
Acid Phosphate		G*	——	14	——	——
Creedmoor	5503	F*	——	14.10	14.39	——
Acid Phosphate		G	——	14	——	——
Binghamton	6360	F	——	14.11	14.41	——
Nitrate of Soda		G	15	——	——	——
Central Islip	5467	F	15	——	——	——
Nitrate of Soda		G	15	——	——	——
Creedmoor	5502	F	15	——	——	——
GERMAN KALI WORKS, NEW YORK, N. Y.						
Muriate of Potash		G	——	——	——	48
Willard	4785	F	——	——	——	50.14
Muriate of Potash		G	——	——	——	48
Brockport	5360	F	——	——	——	49.32
Sulphate of Potash		G	——	——	——	47
Mt Kisco	5610	F	——	——	——	48.64
GRIFFITH & BOYD CO., BALTIMORE, MD.						
Griffith & Boyd Co.'s Fish Bone and Potash		G	1.50	7	8	3
Victor	6010	F	1.66	7.88	9.82	3.40
Griffith & Boyd Co.'s Gilt Edge Crop Guano		G	1.65	8	9	10
Livonia Center	6048	F	1.48	8.41	10.50	8.44
Griffith & Boyd Co.'s High Grade Acid Phosphate		G	——	14	15	——
Victor	6011	F	——	16	16.58	——
Griffith & Boyd Co.'s Royal Potash Guano		G	0.85	8	9	4
Livonia Center	6047	F	0.87	8.51	10.07	4.60
Griffith & Boyd Co.'s Royal 10–8 Mixture		G	——	10	11	8
Merrifield	6523	F	——	11.74	13.30	6.52

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer: Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
Griffith & Boyd Co., Baltimore, Md. (*concluded*)						
Griffith & Boyd Co.'s Special Guano		G*	1.65	8	9	5
Merrifield	6521	F*	1.73	9.45	10.65	4.22
Guile, C. R., Fulton, N. Y.						
Fertilizer		G	——	——	——	——
Darien Center	6460	F	1.07	0.68	0.76	3.11
Hammonds Paint & Slug Shot Works, Beacon, N. Y.						
Sward Food		G	2.35	4.50	5.50	4.60
Beacon	4801	F	2.48	5.94	6.88	4.54
Haserot Canneries Co., The, Cleveland, O.						
Horse Head Brand Pulverized Phosphate Untreated Rock		G	——	——	29.80	——
Attica	3188	F	——	——	31.50	——
Haxstun, R. B., Fort Edward, N. Y.						
Haxstun Bone Meal Fertilizer		G	3.60	——	24.50	——
Fort Edward	5321	F	3.55	——	14.26	——
Henderson & Co., Peter, New York, N. Y.						
Henderson's Cabbage and Cauliflower Fertilizer		G	4.11	7	8	7
New York	6110	F	4.49	8.11	8.49	6.61
Henderson's Corn Fertilizer		G	2.47	10	11	5
New York	6108	F	2.61	11.26	12.52	5.12
Henderson's Fruit and Shade Tree Fertilizer		G	1.65	5	7	10
New York	6116	F	1.63	6.29	8.07	11.72
Henderson's Garden Fertilizer		G	4.12	7	8	5
New York	6105	F	4.54	7.03	7.93	5.46
Henderson's Plant Food Tablets		G	7	7	——	7
New York	6114	F	9.29	10.58	10.72	7.68
Henderson's Potato Fertilizer		G	3.70	7	8	8
New York	6107	F	3.83	7.62	8.36	8.02
Henderson's Raw Ground Bone		G	2.47	——	20	——
New York	6112	F	2.51	——	22.54	——

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
HENDERSON & CO., PETER, NEW YORK, N. Y. (*concluded*)						
Henderson's Raw Bone Meal		G*	2.47	——	20	——
New York	6111	F*	3.38	——	25.48	——
Henderson's Special Blood and Bone Fertilizer		G	3.29	——	17	——
New York	6113	F	3.90	——	21.30	——
Henderson's Universal Superphosphate		G	2.47	8	9	4
New York	6109	F	2.59	8.45	9.77	4.28
Henderson's Worm Killing Grass Food		G	2.36	0.40	0.70	1.80
New York	6115	F	2.53	0.58	0.66	1.92
Nitrate of Soda		G	15	——	——	——
New York	6117	F	15.19	——	——	——
The Henderson Lawn Enricher		G	2.47	3.50	4.50	2.50
New York	6106	F	2.56	4.41	5.53	2.68
HESS & BRO., INC., S. M., PHILADELPHIA, PA.						
Ammoniated Superphosphate		G	1.65	8	9	2
Glen Cove	5409	F	1.71	8.92	9.76	2.36
Cauliflower Manure		G	4.11	5	6	5
Laurel	5513	F	3.81	5.60	6.44	4.84
Farmer's Grain & Clover Grower		G	——	10	11	8
Clyde	4766	F	——	10.33	10.71	8.24
High Grade Ground Bone		G	3.29	——	20.59	——
Glen Cove	5406	F	3.26	——	24.28	——
Nitrate of Soda		G	15	——	——	——
Hicksville	5426	F	15.42	——	——	——
Potato and Truck Manure		G	2.47	8	9	6
Glen Cove	5407	F	2.50	8.58	9.44	5.38
Special Cabbage Manure		G	3.29	6	7	4
Hicksville	5423	F	3.39	6.40	7.78	4.54

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER			
			Nitrogen	Phosphoric acid Available	Phosphoric acid Total	Potash
HESS & BRO., INC., S. M., PHILADELPHIA, PA. (*concluded*)						
Special Compound		G*	0.82	8	9	4
Glen Cove	5408	F*	0.98	8.23	9.05	4.54
Special Corn Manure		G	0.82	8	9	2
Jamestown	5094	F	0.92	8.22	9.88	2.58
Special Fish and Potash Manure		G	2.06	8	9	3
Hicksville	5425	F	2.42	8.10	9.44	3.38
Superior Potash Mixture		G	1.65	8	9	10
Clyde	4767	F	1.30	8.39	9.02	9.32
Special Potato Manure		G	3.29	8	9	7
Hicksville	5401	F	3.37	8.16	9.24	7.36
Wheat and Grass Manure		G	0.82	8	9	2
Jamestown	5095	F	1.02	7.99	9.69	2.16
HOWARD, J. W., SOMERVILLE, MASS.						
Sheep Manure		G	——	——	——	——
Newark	6467	F	1.39	0.17	0.25	3.20
HUBBARD FERTILIZER CO., THE, BALTIMORE, MD.						
Hubbard's Blood, Bone and Potash		G	3.28	8	——	7
Palmyra	5369	F	3.06	7.98	8.58	7.68
Hubbard's Climax Phosphate		G	0.82	7	8	4
Summitt	5247	F	0.97	7.65	8.03	4.02
Hubbard's Farmer's I X L		G	1.64	8	——	2
Palmyra	5371	F	1.78	8.32	8.80	2.12
Hubbard's 14% Phosphate		G	——	14	——	——
Windsor	5877	F	——	15.10	15.91	——
Hubbard's Jersey Trucker		G	1.64	8	——	10
Palmyra	5368	F	1.85	8.06	8.42	10.94
Hubbard's 12–5 Alkaline		G	——	12	——	5
Windsor	5876	F	——	12.16	13.38	4.69

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer: Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
Hudson Carbon Co., Ballston Spa., N. Y.						
Davidge's Concentrated Manure		G*	1	——	1	——
Mt. Kisco	5614	F*	1.43	——	8.22	——
Davidge's Special Phosphorus		G	——	——	5	——
Ballston Spa.	5663	F	——	——	14.16	——
International Agricultural Corporation, Buffalo, N. Y.						
Bedford Farmers Four Ten Eight		G	3.30	10	11	8
Mt Kisco	5612	F	2.99	9.81	10.83	7.94
Bedford Farmers Three Eight Six		G	2.40	8	9	6
Mt. Kisco	5613	F	2.43	8.41	10.07	5.71
I. A. C. Four Ten Four		G	3.30	10	11	4
Springville	5939	F	3.27	9.61	10.97	5.82
I. A. C. Three Ten Eight		G	2.40	10	11	8
Springville	5940	F	2.53	9.91	10.79	7.94
I. A. C. Two Nine Four		G	1.60	9	10	4
Springville	5938	F	1.71	9.39	11.67	3.98
International Agricultural Corporation, Buffalo Fertilizer Works, Buffalo, N. Y.						
Animal Tankage		G	6.10	——	——	——
Mount Morris	6049	F	7.46	——	——	——
Bone Meal		G	2.40	——	22	——
Collins	5057	F	2.39	——	22.82	——
Celery and Potato Special		G	1.60	8	9	10
Silver Springs	4519	F	1.49	8.11	9.31	10.34
Celery and Potato Special		G	1.60	8	9	10
Thiells	5499	F	1.64	8.35	10.01	10.30
Dissolved Phosphate		G	——	14	15	——
Watertown	5192	F	——	14.59	15.11	——
Dissolved Phosphate		G	——	14	15	——
Owego	6359	F	——	16.10	16.52	——

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
INTERNATIONAL AGRICULTURAL CORPORATION, BUFFALO FERTILIZER WORKS, BUFFALO, N.Y. (*continued*)						
Dried Blood Utica	4236	G* F*	9.84 9.96	— —	— —	— —
Dried Blood Rochester	4541	G F	9.84 10.16	— —	— —	— —
Dried Blood Willard	4787	G F	9.84 10.11	— —	— —	— —
Dried Blood Collins	5054	G F	9.84 10.27	— —	— —	— —
Dried Blood Kings Park	5416	G F	9.84 10.39	— —	— —	— —
Dried Blood Creedmoor	5448	G F	9.84 10.43	— —	— —	— —
Dried Blood Central Islip	5469	G F	9.84 10.14	— —	— —	— —
Dried Blood Yorktown	5470	G F	9.84 10.20	— —	— —	— —
Dry Ground Fish South Lima	6044	G F	6.58 5.62	— —	— —	— —
Extra Phosphate and Potash Silver Springs	3199	G F	— —	10 10.29	11 10.65	8 7.43
Farmers Choice Richfield Springs	4241	G F	0.80 1.18	8 8.66	9 10.20	5 6.45
Fish Guano Silver Springs	4521	G F	0.80 1.12	9 9.77	10 11.67	2 2.72
Garbage Tankage Fairport	5378	G F	2.25 2.75	— —	4 3.44	0.75 1.00

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
International Agricultural Corporation, Buffalo Fertilizer Works, Buffalo, N.Y. (*continued*)						
Garden Truck		G*	3.30	8	9	7
Watertown	5188	F*	3.27	7.43	10.30	7.62
Garden Truck		G	3.30	8	9	7
Thiells	5501	F	3.28	8.46	10.20	6.49
General Crop		G	——	9	10	3
Sharon Springs	5213	F	——	9.31	10.71	3.10
General Favorite		G	1.20	8	9	2.50
Collins	5059	F	1.41	8.42	9.76	2.80
High Grade Manures		G	3.30	7	8	10
Richfield Springs	4240	F	3.05	7.46	9.18	9.98
Ideal Wheat and Corn		G	1.60	9	10	5
Silver Springs	4522	F	1.60	9.53	10.97	5.02
Ideal Wheat and Corn		G	1.60	9	10	5
Thiells	5500	F	1.64	8.84	10.25	6
Kainit		G	——	——	——	12
Batavia	5384	F	——	——	——	13.84
Muriate of Potash		G	——	——	——	48
Silver Springs	4520	F	——	——	——	53.50
Nitrate of Soda		G	15	——	——	——
Fairport	5377	F	14.98	——	——	——
Phosphate and Potash		G	——	12	13	5
Clyde	4760	F	——	12.75	13.33	4.33
Potato and Truck Manure		G	1.60	8	9	6
Penn Yan	4913	F	1.91	7.85	9.44	5.50
Sulphate of Ammonia		G	20.50	——	——	——
Mount Morris	6050	F	20.44	——	——	——

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
INTERNATIONAL AGRICULTURAL CORPORATION, BUFFALO FERTILIZER WORKS, BUFFALO, N. Y. (*concluded*)						
Sulphate of Potash		G*	—	—	—	48
South Lima	6045	F*	—	—	—	50.28
Top Dresser		G	5.70	6	7	5
Richfield Springs	4242	F	5.73	5.74	7.20	5.56
Top Dresser		G	5.70	6	7	5
Penn Yan	4903	F	4.61	6.79	8.37	5.45
Vegetable and Potato		G	2.40	8	9	7
Norwich	5829	F	2.39	8.32	10.14	7.24
INTERNATIONAL AGRICULTURAL CORPORATION, PENNSYLVANIA FERTILIZER BRANCH, BUFFALO, N. Y.						
Acid Phosphate		G	—	12	13	—
Romulus	6540	F	—	12.22	13.14	—
Big Bonanza		G	0.80	8	9	4
Canaseraga	4529	F	0.82	8.26	9.50	4.08
Economy		G	1.60	8	9	4
Campbell	4949	F	1.68	8.87	10.39	4.72
Empire 10%		G	1.60	8	9	10
Horseheads	4936	F	1.62	8.76	9.82	9.74
Four Fold		G	0.80	8	9	2
Mallory	5787	F	0.94	9.70	10.90	2.34
Gardener's Special		G	2.40	6	7	10
Canaseraga	4527	F	2.71	6.41	7.65	10
Grain and Grass		G	—	10	11	2
Romulus	6538	F	—	9.79	10.71	2.14
Potato and Truck Manure		G	1.60	8	9	6
Clarence	5905	F	1.59	8.10	10.14	5.98
Vegetable and Vine		G	0.80	10	11	8
Clarence	5904	F	1.28	9.13	11.06	7.92

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
International Seed Co., Rochester, N. Y.						
International A 1 Special Manure		G*	2.47	6	7	10
Arkport	6464	F*	2.54	5.92	7.85	9.37
International Crop Grower		G	0.83	7	8	1
Darien Center	4742	F	0.92	6.94	8.38	2.81
International Electric Fertilizer		G	0.82	8	9	2
Darien	4739	F	1.03	7.45	9.12	2.32
International Grain and Grass Fertilizer		G	1.23	10	11	2.50
Darien Center	4741	F	1.57	9.43	11.16	2.61
International Potato and Truck Manure		G	1.23	8	9	7
Darien Center	4740	F	1.38	7.66	8.91	7.72
Jarecki Chemical Co., The, Sandusky, O.						
Black Diamond Fish Guano		G	1.66	8	——	4
South Byron	4539	F	1.73	9.28	9.82	4.22
Fish and Potash Garden Fertilizer		G	1.66	8	——	10
Clyde	4763	F	1.62	8.89	9.31	10.88
Fish and Potash General Grower		G	0.83	7	——	3
Warsaw	3191	F	0.84	6.97	7.32	4.57
Fish and Potash General Grower		G	0.83	7	——	3
Eden Center	5072	F	0.81	8.02	8.48	2.92
Fish and Potash Grain Special		G	0.83	8	——	4
Lockport	5912	F	0.83	8.67	9.14	2.09
Fish and Potash Truck Manure		G	3.33	8	——	7
Charlotte	4550	F	3.37	8.37	8.67	6.70
Humus Phosphate with Potash		G	0.20	10	——	8
Charlotte	5351	F	0.31	9.61	10.39	8.84
Special Cabbage and Onion Guano		G	0.83	10	——	8
Walker	4549	F	0.86	10.25	10.65	8.04

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
LISTERS AGRICULTURAL CHEMICAL WORKS, NEWARK, N. J.						
Lister's Ammoniated Dissolved Superphosphate		G*	2.06	8	9	1.50
Cooperstown	4247	F*	2.14	8.31	9.37	1.60
Lister's Bone Meal		G	2.67	——	22.88	——
New Rochelle	5622	F	2.63	——	27.68	——
Lister's Buyers' Choice Acid Phosphate		G	——	14	15	——
Corning	4932	F	——	14.31	15.37	——
Lister's Cauliflower and Cabbage Fertilizer		G	3.29	8	9	7
Webster Station	5833	F	3.37	7.80	9.18	7.92
Lister's Celebrated Ground Bone and Tankage Acidulated		G	2.67	6	12	——
Huntington	5430	F	2.90	10.20	12.50	——
Lister's Corn and Potato Fertilizer		G	1.65	8	9	3
Cherry Valley	5222	F	1.92	7.33	8.90	3.08
Lister's Corn No. 2 Fertilizer		G	1.65	10	11	4
Attica	4750	F	1.74	10.49	11.83	4.34
Lister's Dissolved Phosphate and Potash		G	——	10	11	2
Cherry Valley	5221	F	——	9.88	10.14	2
Lister's Excelsior Guano		G	0.82	9	10	7
Phelps	4906	F	0.99	8.91	9.69	7.42
Lister's G Brand		G	0.82	8	9	4
Spencerport	4746	F	0.94	8.53	9.95	4.20
Lister's Grain and Grass Fertilizer		G	——	9	10	5
Utica	4230	F	——	9.05	9.31	5.55
Lister's High Grade Dry Blood		G	9.87	——	——	——
Fairport	5375	F	10.07	——	——	——
Lister's New York Special Fertilizer		G	0.82	8	9	10
Byron	4540	F	0.94	8.39	8.99	10.38

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 — (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer: Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
Listers Agricultural Chemical Works, Newark, N. J. (*continued*)						
Lister's New York Special Fertilizer		G*	0.82	8	9	10
Ballston	5662	F*	0.91	8.72	9.56	10.18
Lister's Oneida Special		G	0.82	7	8	1
Catskill	5691	F	1.05	7.08	8.10	1.20
Lister's Orchard Fertilizer		G	——	6	7	10
Spencerport	4745	F	——	6.52	6.82	10.90
Lister's Potato Manure		G	3.29	8	9	7
Phelps	4908	F	3.35	8.17	9.31	7.70
Lister's Potato Manure		G	3.29	8	9	7
Huntington	5429	F	3.42	8.36	9.44	7.68
Lister's Potato No. 2 Fertilizer		G	1.65	10	11	4
Utica	4229	F	1.82	10.59	11.99	4.16
Lister's Reliance		G	1.03	8	9	2
Trumansburg	6171	F	1.24	8.25	9.31	2.06
Lister's Special 10% Potato Fertilizer		G	1.63	8	9	10
Pittsford	4743	F	1.68	8.11	9.95	11.17
Lister's Special Wheat Fertilizer		G	1.65	8	9	3
West Bloomfield	6007	F	1.78	8.02	9.56	3.40
Lister's Standard Pure Superphosphate of Lime		G	2.47	9	10	2
Spencerport	4747	F	2.46	9.33	10.27	2.29
Lister's Success Fertilizer		G	1.23	9	10	2
Cherry Valley	5223	F	1.40	9.18	10.58	2.32
Lister's Superior Dissolved Phosphate and Potash		G	——	10	11	8
Spencerport	4748	F	——	10.23	10.49	8.70
Lister's 10% Potato Grower		G	3.29	6	7	10
Waterville	5558	F	3.44	7.18	8.16	9.69
Lister's 3-6-10 for Potatoes		G	2.47	6	7	10
Ballston	5661	F	2.49	6.93	8.03	10.72

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER			
			Nitrogen	Phosphoric acid Available	Phosphoric acid Total	Potash
LISTERS AGRICULTURAL CHEMICAL WORKS, NEWARK, N. J. (*concluded*)						
Lister's 2-5-10 Fertilizer		G*	1.65	5	6	10
Cortland	4444	F*	1.78	4.49	5.23	10.24
Lister's U. S. Superphosphate		G	1.03	8	9	2
Sherburne	5807	F	1.18	7.97	9.09	2.82
Muriate of Potash		G	——	——	——	49
Fairport	5376	F	——	——	——	49.80
Nitrate of Soda		G	15	——	——	——
Cortland	4446	F	15.66	——	——	——
LOWELL FERTILIZER CO., BOSTON, MASS.						
Kainit		G	——	——	——	12
Binghamton	5883	F	——	——	——	12.54
Kainit		G	——	——	——	12
Arkport	6465	F	——	——	——	12.76
Lowell Animal Brand for All Crops		G	2.46	8	9	4
East Meredith	6407	F	2.41	8.41	9.05	4.88
Lowell Bone Fertilizer for Corn, Grain, Grass and Vegetables		G	1.64	8	9	3
Cortland	6333	F	1.79	8.20	9.56	3.62
Lowell Cereal Fertilizer		G	0.82	7	8	1
Boonville	5570	F	0.86	6.88	7.60	1.23
Lowell Cereal Fertilizer		G	0.82	7	8	1
Cortland	6331	F	0.94	6.92	7.52	1.28
Lowell Corn and Vegetable		G	3.28	8	9	7
Middle Granville	5671	F	3.32	8.32	9.12	6.92
Lowell Express Brand for Corn, Potatoes and Grain		G	1.24	7	8	2
Cortland	6335	F	1.27	7.27	7.71	2.02
Lowell Grain Phosphate		G	——	10	11	8
Middle Granvillle	5669	F	——	11.33	11.67	7.90

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid Available	Phosphoric acid Total	Potash
Lowell Fertilizer Co., Boston, Mass. (*continued*)						
Lowell Ground Bone		G*	2.46	——	23	——
Binghamton	5862	F*	3.22	——	24.86	——
Lowell Potato Grower with 10% Potash		G	3.28	6	7	10
Union	6157	F	3.30	6.35	6.79	9.74
Lowell Potato Manure		G	1.64	7	8	4
Cortland	6334	F	1.74	7.61	8.29	4.44
Lowell Potato Phosphate		G	2.46	8	9	6
McLean	4450	F	2.53	8.13	8.94	6.46
Lowell Soluble Phosphate		G	——	12	13	——
Corbettsville	6393	F	——	13.40	13.90	——
Lowell Special Grass Mixture for Top Dressing and Lawns		G	4.10	7	8	6
Middle Granville	5670	F	4.09	7.24	8.10	6.32
Lowell Special Potato Fertilizer		G	2.46	6	7	10
Watertown	5193	F	2.49	6.15	6.63	9.84
Lowell Sterling Phosphate		G	0.82	8	9	4
Boonville	5569	F	0.96	8.12	8.81	3.85
Lowell Sterling Phosphate		G	0.82	8	9	4
Cortland	6330	F	0.90	7.81	8.62	4.18
Lowell Superior Fertilizer		G	3.69	7	8	10
Copenhagen	3781	F	3.51	7.32	8.10	9.65
Lowell Vegetable and Grain Fertilizer		G	1.64	8	9	10
Boonville	5571	F	1.77	8.31	8.73	9.64
Lowell Vegetable and Grain Fertilizer		G	1.64	8	9	10
Cortland	6332	F	1.66	8.87	9.31	9.70
Muriate of Potash		G	——	——	——	50
Binghamton	5861	F	——	——	——	50.40

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
LOWELL FERTILIZER CO., BOSTON, MASS. (*concluded*)						
Nitrate of Soda		G*	15	——	——	——
Union	6159	F*	15.27	——	——	——
6–30 Ground Tankage		G	5	——	14	——
Arkport	6463	F	5.05	——	14.99	——
LUDLAM CO., FREDERICK, NEW YORK, N. Y.						
Ludlam's A. B. F. Fertilizer		G	1.65	8	9	2
Babylon	5543	F	1.58	8.66	9.82	2.62
Ludlam's Antler Fertilizer		G	3.29	6	7	10
Hale Eddy	5848	F	3.29	6.62	7.52	10.08
Ludlam's Cecrops Fertilizer		G	3.29	7	8	7
Aquebogue	5495	F	3.41	6.91	8.61	6.72
Ludlam's Fruit and Vine Fertilizer		G	0.82	8	9	10
Hale Eddy	5849	F	0.92	8.10	10.20	10.58
Ludlam's Palmetto Fertilizer		G	0.82	8	9	4
Mexico	5792	F	0.92	7.99	8.93	4.18
Ludlam's P. G. Phosphate		G	——	10	11	6
Mexico	5793	F	——	10.07	10.65	4.43
Nitrate of Soda		G	15	——	——	——
Calverton	5507	F	15.02	——	——	——
LYON, S. G., AURORA, N. Y.						
S. G. Lyon's Ammoniated Bone Super-Phosphate		G	1.22	8	9	3
Aurora	6527	F	1.50	9.34	11.48	2.86
MAPES FORMULA & PERUVIAN GUANO CO., THE, NEW YORK, N. Y.						
Mapes General Crop Brand		G	1.65	8	10	2
Binghamton	6302	F	1.81	8.17	10.65	2.62
Mapes Grain Brand		G	0.82	8	——	4
Honeoye Falls	6008	F	1.00	8.33	9.63	4.68

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
MAPES FORMULA & PERUVIAN GUANO CO., THE, NEW YORK, N. Y. (*continued*)						
Pure Ground Bone		G*	2.47	——	20	——
Sayville	5540	F*	3.24	——	26.52	——
The Mapes Average Soil Complete Manure		G	4.12	7	8	5
Floral Park	5455	F	4.25	7.09	8.03	6.72
The Mapes Cauliflower and Cabbage Manure		G	4.12	6	——	6
Mattituck	5488	F	4.39	5.88	6.76	6.79
The Mapes Cereal Brand		G	1.65	6	8	3
Mt. Kisco	5615	F	1.83	5.97	9.69	3.34
The Mapes Complete Manure " A " Brand		G	2.47	10	12	2.50
Coxsackie	5697	F	2.66	9.53	12.43	3.36
The Mapes Complete Manure 10% Potash		G	2.06	3	5	10
Binghamton	6301	F	2.63	4.04	5.74	11.16
The Mapes Corn Manure		G	2.47	8	10	6
Hicksville	5463	F	2.68	9.03	10.81	6.62
The Mapes Dissolved Bone		G	2.06	12	——	——
Mattituck	5487	F	2.49	17.40	19.26	——
The Mapes Economical Potato Manure		G	3.29	4	6	8
Baldwinsville	6153	F	3.52	4.50	6.76	8.44
The Mapes Lawn-Top Dressing		G	2.47	2	3.50	2.50
Sayville	5539	F	2.58	3.39	4.33	4.08
The Mapes Nitrogenized Super-Phosphate		G	2.06	9	11	2.50
Coxsackie	5698	F	2.04	8.81	12.05	2.62
The Mapes Potato Manure (L. I. Special)		G	3.29	4	6	7
Floral Park	5456	F	3.60	6.45	7.59	7.54

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER			
			Nitrogen	Phosphoric acid Available	Phosphoric acid Total	Potash
MAPES FORMULA & PERUVIAN GUANO CO., THE, NEW YORK, N. Y. (*concluded*)						
The Mapes Potato Manure		G*	3.71	8	——	6
Coxsackie	5699	F*	3.87	8.14	9.24	6.64
The Mapes Tobacco Starter Improved		G	4.12	6	8	1
Baldwinsville	6154	F	4.50	7.49	8.93	2.94
The Mapes Top Dresser — Improved Full Strength		G	9.88	5	8	4
Mattituck	5486	F	9.81	7.31	8.71	4.30
The Mapes Top Dresser — Improved Half Strength		G	4.94	2.50	4	2
White Plains	5616	F	4.45	3.32	4.72	2.62
MARTIN CO., D. B., PHILADELPHIA, PA.						
Martin's Acid Phosphate		G	——	14	14.75	——
Penn Yan	4919	F	——	14.02	14.41	——
Martin's Dissolved Organic Compound		G	1.03	9	——	2
Branchport	6543	F	1.08	9.52	10.84	2.12
Martin's High Grade Potato Manure		G	3.30	8	——	10
Branchport	6544	F	3.27	8.69	9.31	9.23
Martin's Potash and Soluble Phosphate		G	——	10	11	8
Penn Yan	4920	F	——	9.97	10.27	6.77
Martin's Special Potato Manure		G	0.82	8	9	5
Penn Yan	4918	F	0.97	8.11	9.56	4.67
McCOY, GEO. E., PEEKSKILL, N. Y.						
An Honest Fertilizer		G	5	——	16	——
Peekskill	5627	F	5.18	——	20.78	——
MILLER FERTILIZER CO., BALTIMORE, MD.						
Club Brand		G	0.42	8	8.50	2
Jamestown	5929	F	0.52	8.33	9.05	2.36

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
Munroe & Sons, Geo. L., Oswego, N. Y.						
Pure Unleached Wood Ashes		G*	——	0.25	0.50	1
Binghamton	5873	F*	——	0.45	0.98	3.26
Nassau Fertilizer Co., New York, N. Y.						
Common Sense Potato Manure		G	1.65	8	9	4
Worcester	5763	F	1.92	8.82	9.76	4.10
Corn Fertilizer		G	1.65	8	9	2
Watertown	5186	F	1.75	8.27	10.07	2.14
General Favorite		G	0.82	9	9	4
Watertown	5187	F	1.07	9.06	10.14	4.12
Gladiator Truck and Potato		G	3.29	7	8	7
Glens Falls	5305	F	3.31	7.49	8.85	6.92
Grass and Grain Fertilizer		G	——	10	11	2
Watertown	5185	F	——	10.24	11.54	2
Soluble Phosphate		G	——	14	15	——
Collins	5055	F	——	13.75	16.01	——
Special Potato Fertilizer		G	1.65	8	9	10
Glens Falls	5307	F	1.80	8.64	10.24	9.98
Ten and Eight Special		G	——	10	11	8
Carthage	5705	F	——	9.91	11.41	8.54
Wheat and Grass Grower		G	0.82	8	9	2
Lowville	3784	F	0.97	7.63	9.69	2.14
National Fertilizer Co., The, New York, N. Y.						
National Complete Root Special "Special"		G	3.29	8	9	7
Calverton	5505	F	3.77	8.66	9.60	7.12
Natural Guano Company Aurora, Ill.						
Sheep's Head Brand Pulverized Sheep Manure		G	2.25	1	1.25	1.50
Rochester	4744	F	2.26	1.24	1.40	2.24

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
NEWBURGH RENDERING CO., NEWBURGH, N. Y.		G*	11	——	——	——
Concentrated Tankage Newburgh	5606	F*	11.98	——	——	——
Pure Meat and Bone Fertilizer		G	4	——	16	——
Newburgh	5607	F	5.25	——	17.83	——
NEWHOF & SON, L., ALBANY, N. Y. Pure Fertilizer		G	5	——	9	——
Albany	5135	F	6.07	——	9.65	——
NEW YORK FERTILIZER CO., BALTIMORE, MD. 14% Acid Phosphate		G	——	14	——	——
Schenevus	5771	F	——	14.84	15.24	——
New York Corn and Grain		G	0.82	8	——	4
Schenevus	5766	F	0.88	8.28	9.88	4.46
New York General Crop Grower		G	0.42	7	——	2
Schenevus	5770	F	0.50	7.29	8.35	2.22
New York Phosphate and Potash		G	——	10	——	8
Hartwick	5785	F	——	10.36	10.78	7.23
New York Potato Guano		G	1.65	8	——	10
Schenevus	5765	F	1.85	7.95	8.73	11.70
New York Potato Guano		G	1.65	8	——	10
New Berlin	5856	F	1.73	8.42	9.24	10.52
New York Special Potato Fertilizer		G	0.82	4	——	8
Hartwick	5784	F	1.06	5.64	6.18	6.82
New York Special Trucker		G	3.29	8	——	6
New Berlin	5854	F	3.10	8.31	8.99	6.26
NEW YORK STATE GRANGE PURCHASING AGENCY, OLEAN, N. Y. Nitrate of Soda		G	14.81	——	——	——
Darien	5394	F	14.94	——	——	——

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
New York State Grange Purchasing Agency, Olean, N. Y. (*continued*)						
Nitrate of Soda		G*	14.81	——	——	——
Cazenovia	5880	F*	15.30	——	——	——
Nitrate of Soda		G	14.81	——	——	——
Chaffee	5957	F	15.39	——	——	——
Patrons P of H 4–8–7		G	3.29	8	8.50	7
Mellinville	4818	F	3.22	8.46	9.90	7.42
Patrons P of H 4–8–7		G	3.29	8	8.50	7
Darien	5392	F	3.34	7.94	8.76	7.18
Patrons P of H 4–8–7		G	3.29	8	8.50	7
Cazenovia	5879	F	3.19	7.96	8.01	8.02
Patrons P of H 14%		G	——	14	14.50	——
Mellinville	4817	F	——	13.23	14.03	——
Patrons P of H 14%		G	——	14	14.50	——
Darien	5393	F	——	15	15.98	——
Patrons P of H 1–8–4		G	0.82	8	8.50	4
Cherry Creek	5084	F	0.89	8.63	9.31	3.74
Patrons P of H 1–8–4		G	0.82	8	8.50	4
Darien	5395	F	0.87	9.07	9.53	4.20
Patrons P of H 10–8		G	——	10	10.50	8
Pleasant Valley	4827	F	——	10.70	10.90	7.53
Patrons P of H 10–8		G	——	10	10.50	8
Darien	5391	F	——	10.10	10.76	7.68
Patrons P of H 10–8		G	——	10	10.50	8
Pierrepont Manor	5715	F	——	10.42	10.58	7.21
Patrons P of H 10–8		G	——	10	10.50	8
Cazenovia	5845	F	——	10.22	10.84	7.31
Patrons P of H 10–8		G	——	10	10.50	8
Dayton	5944	F	——	10.51	10.83	7.77

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer: Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
NEW YORK STATE GRANGE PURCHASING AGENCY, OLEAN, N. Y. (*concluded*)						
Patrons P of H 2–8–5		G*	1.65	8	8.50	5
Fort Covington	3776	F*	1.59	7.71	9.95	5.34
Patrons P of H 2–8–5		G	1.65	8	8.50	5
Darien	5396	F	1.87	7.45	8.93	5.44
Patrons P of H 2–8–5		G	1.65	8	8.50	5
Cazenovia	5843	F	1.67	8.16	8.86	5.38
Patrons P of H 2–8–10		G	1.65	8	8.50	10
Mellinville	4816	F	1.64	8.72	9.12	10.40
Patrons P of H 2–8–10		G	1.65	8	8.50	10
Darien	5397	F	1.55	8.33	9.37	10.78
Patrons P of H 2–8–10		G	1.65	8	8.50	10
Pierrepont Manor	5716	F	1.61	8.43	8.73	10.44
Patrons 2–8–10		G	1.65	8	8.50	10
Pulaski	5791	F	1.59	7.98	8.86	10
Patrons P of H 2–8–10		G	1.65	8	8.50	10
Cazenovia	5844	F	1.62	8.44	9.12	10.04
Patrons P of H 2–8–10		G	1.65	8	8.50	10
Dayton	5943	F	1.64	8.45	9.19	9.40
Patrons P of H 2–8–10		G	1.65	8	8.50	10
Chaffee	5956	F	1.69	8.25	8.71	10.49
NIANTIC MENHADEN OIL & GUANO CO., THE, SOUTH LYME, CONN.						
Bone Fish and Potash		G	2.46	5	6	3
Orient	5525	F	2.55	5.86	7.08	3.42
NITRATE AGENCIES CO., NEW YORK, N. Y.						
Dried Blood		G	13.16	——	——	——
Brockport	5361	F	13.63	——	——	——
Dried Fish		G	9.23	——	6.35	——
Riverhead	5485	F	9.75	——	7.30	——

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
NITRATE AGENCIES CO., NEW YORK, N. Y. (*continued*)						
Ground Bone		G*	2.46	——	22.88	——
Williamson	6026	F*	3.67	——	22.58	——
Ground Tankage		G	5.75	——	13.73	——
Berne	5137	F	5.88	——	13.44	——
Ground Tankage		G	5.85	——	13.57	——
Riverhead	5484	F	5.46	——	20.05	——
H. A. Brand Basic Slag		G	——	†14	17	——
Mt. Kisco	5700	F	——	——	19.26	——
High Grade Acid Phosphate		G	——	14	——	——
Brockport	5358	F	——	15.33	16.07	——
High Grade Acid Phosphate		G	——	16	——	——
Riverhead	5481	F	——	16.39	16.53	——
High Grade Acid Phosphate		G	——	14	——	——
Orchard Park	5902	F	——	13.99	16.07	——
Muriate of Potash		G	——	——	——	50
Utica	4237	F	——	——	——	51.60
Muriate of Potash		G	——	——	——	50
Rochester	4542	F	——	——	——	50.52
Muriate of Potash		G	——	——	——	50
Poughkeepsie	4811	F	——	——	——	53.40
Muriate of Potash		G	——	——	——	50
Ogdensburg	5252	F	——	——	——	46.60
Muriate of Potash		G	——	——	——	50
Kings Park	5415	F	——	——	——	53.16
Muriate of Potash		G	——	——	——	50
Creedmoor	5446	F	——	——	——	49.10
Muriate of Potash		G	——	——	——	49
Central Islip	5468	F	——	——	——	50.06

* These letters indicate, respectively, Guaranteed and Found.
† No official method for determining available P_2O_5 in this sample.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
NITRATE AGENCIES CO., NEW YORK, N. Y. (*concluded*)						
Muriate of Potash		G*	——	——	——	50
Yorktown	5472	F*	——	——	——	47.64
Muriate of Potash		G	——	——	——	49
Binghamton	6361	F	——	——	——	51.78
Nitrate of Soda		G	15	——	——	——
Willard	4786	F	15.24	——	——	——
Nitrate of Soda		G	15	——	——	——
Ogdensburg	5251	F	15.50	——	——	——
Nitrate of Soda		G	15	——	——	——
Brockport	5359	F	15.19	——	——	——
Nitrate of Soda		G	15	——	——	——
Binghamton	6362	F	15.51	——	——	——
PATAPSCO GUANO CO., BALTIMORE, MD.						
Coon Brand Guano		G	0.82	9	10	3
Oxford	5819	F	1.24	9.44	10.80	3.14
Patapsco Alkaline Plant Food		G	——	8	9	5
Williamstown	5795	F	——	8.13	8.67	4.67
Patapsco Cabbage and Asparagus Guano		G	2.47	8	9	6
Sherburne	6397	F	2.65	8.74	9.88	6.88
Patapsco Empire Alkaline Bone		G	——	12	13	5
North Norwich	5808	F	——	12.09	13.01	4.84
Patapsco Fish and Potash Guano		G	1.65	8	9	2
Cazenovia	5834	F	1.74	8.29	10.01	2.12
Patapsco Grain and Grass Producer		G	0.82	8	——	4
Remsen	5576	F	0.84	9.23	10.65	4.14
Patapsco Grain and Grass Producer		G	0.82	8	9	4
Sherburne	6396	F	0.98	8.58	10.46	4.32
Patapsco O. K. Phosphate		G	0.82	8	9	2
Knox	5652	F	0.97	8.08	9.76	2.12

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer: Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
Patapsco Guano Co., Baltimore, Md. (*concluded*)						
Patapsco Peerless Potato Guano		G*	3.29	6	7	10
Sherburne	6398	F*	3.38	6.50	8.28	10.90
Patapsco Prolific Potato Phosphate		G	3.29	8	9	7
Cazenovia	5835	F	3.40	8.75	10.07	6.92
Patapsco Pure Dissolved S. C. Phosphate		G	——	14	15	——
South New Berlin	5857	F	——	15.58	16.58	——
Patapsco Special Potato Guano		G	1.65	8	9	10
Remsen	5577	F	1.71	8.49	10.33	10.38
Patapsco Superior Alkaline Manure		G	——	10	11	8
Cooperstown	4250	F	——	10.43	11.35	7.39
Patapsco Superior Alkaline Manure		G	——	10	11	8
Knox	5653	F	——	10.25	11.29	8.04
Patapsco Vegetable and Corn Fertilizer		G	1.65	8	9	4
Cooperstown	4249	F	1.74	7.72	9.18	4.18
Patapsco Vegetable and Corn Fertilizer		G	1.65	8	9	4
Sherburne	6317	F	1.59	7.22	9.12	4.20
Piedmont–Mt. Airy Guano Co., Baltimore, Md.						
Bone Tankage		G	8.23	——	——	——
Ontario	6028	F	9.22	——	——	——
Levering's Standard		G	1.65	8	——	3
Cincinnatus	6376	F	1.64	9.03	9.63	4.04
Muriate of Potash		G	——	——	——	50
North Rose	6024	F	——	——	——	51.32
New York Cabbage and Potato Guano		G	1.65	8	——	10
Owego	6358	F	1.72	9.02	9.44	9.09
New York Vegetable Manure		G	3.29	8	——	6
Orchard Park	5015	F	3.50	8.64	9.44	6.88

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
PIEDMONT-MT. AIRY GUANO CO., BALTIMORE, MD. (*continued*)						
New York Early Vegetable Manure		G*	4.12	8	——	5
Hicksville	5427	F*	4.08	8.84	9.18	5.84
Piedmont Banner Brand		G	3.29	6	——	10
Hicksville	5428	F	3.31	6.65	7.33	11.60
Piedmont Celery and Vegetable Compound		G	2.47	6	——	10
Orchard Park	5017	F	2.44	6.81	7.13	10.92
Piedmont Complete Fertilizer		G	2.47	7	——	5
Hicksville	5465	F	2.63	8.32	8.84	6
Piedmont Farmers Favorite		G	0.82	8	——	4
Owego	6357	F	0.92	9.34	9.82	4.68
Piedmont 14% Acid Phosphate		G	——	14	——	——
East Bloomfield	6014	F	——	15.12	15.34	——
Piedmont General Crop Grower		G	1	8	——	2
Sidney	5860	F	1.27	8.51	9.63	2.18
Piedmont Grain and Grass Guano		G	1.25	9	——	2.50
Hamlin	6016	F	1.17	9.07	10.01	2.82
Piedmont Long Island Special		G	3.29	7	——	7
Eden	5024	F	3.20	8.60	9.76	8.22
Piedmont Long Island Special		G	3.29	7	——	7
Hicksville	5464	F	3.28	7.73	8.61	8.22
Piedmont Market Garden Manure		G	2.47	8	——	6
Eden	5025	F	2.51	8.39	9.84	6.63
Piedmont Oat and Grass Guano		G	——	10	——	2
Romulus	6539	F	——	9.93	10.01	2.28
Piedmont Pea and Bean Grower		G	0.82	7	——	9
New Berlin	5853	F	0.92	7.59	8.29	9.14
Piedmont Perfection Guano		G	1.65	8	——	5
Chaumont	5707	F	1.71	8.88	9.88	5.26
Piedmont Special Mixture		G	——	10	——	8
Owego	6356	F	——	10.69	10.97	7.61

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
Piedmont–Mt. Airy Guano Co., Baltimore, Md. (*concluded*)						
Piedmont Wheat and Corn Guano		G*	1.65	8	——	2
Darien	5389	F*	1.50	8.53	9.93	2.60
Piedmont Wheat Compound		G	——	12	——	5
Port Gibson	5373	F	——	11.93	12.43	5.06
Thomas Phosphate Powder (Basic Slag Phosphate)		G	——	†15	17	——
East Bloomfield	6015	F	——	——	17.92	——
Pine & Son, B. J., East Williston, L. I.						
Pine's No. 1 Star Raw Bone Super Phosphate Complete Manure		G	3.29	7	8	7
East Williston	5437	F	3.45	7.74	9.44	7.12
Pine's No. 2 Star Raw Bone Super Phosphate Complete Manure		G	2.25	6	7	3
East Williston	5438	F	2.53	7.34	9.12	3.40
Pulverized Manure Co., The, Chicago, Ill.						
Wizard Brand Pulverized Sheep Manure		G	1.80	1	——	1
Syracuse	6329	F	2.20	1.35	1.43	2.05
Rasin Monumental Co., Baltimore, Md.						
King Guano		G	2.06	8	9	1.50
Vernon	5757	F	2.14	7.76	9.16	1.78
Muriate of Potash		G	——	——	——	48
Cobleskill	5122	F	——	——	——	49.80
Nitrate of Soda		G	14.82	——	——	——
Cortland	6151	F	14.82	——	——	——
Rasin's Acid Phosphate		G	——	14	15	——
Penn Yan	4922	F	——	14.82	15.94	——
Rasin's All Crop Guano		G	0.82	8	9	5
Greene	5837	F	1.12	8.68	10.10	5.10
Rasin's Bone and Potash Fertilizer		G	——	10	11	2
East Berne	5248	F	——	10.16	11.60	2.34

* These letters indicate, respectively, Guaranteed and Found.
† No official method of determining available P_2O_5 in this sample.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER			
			Nitrogen	Phosphoric acid		Potash
				Available	Total	
RASIN MONUMENTAL CO., BALTIMORE, MD. (*continued*)						
Rasin's Empire Guano		G*	1.65	8	9	2
McLean	4448	F*	1.68	9.47	10.27	2.40
Rasin's Genesee Valley Root Manure		G	0.82	8	9	10
Delanson	5127	F	1.02	8.61	10.39	10.52
Rasin's Genuine German Kainit		G	——	——	——	12
Cobleskill	5109	F	——	——	——	11.90
Rasin's Gold Standard		G	2.47	6	7	6
McLean	4447	F	2.15	6.97	8.24	5.24
Rasin's High Grade Bone and Potash		G	——	12	13	5
East Berne	5250	F	——	12.69	14.09	5.06
Rasin's Irish Potato Special		G	3.29	7	8	8
Moravia	6501	F	3.28	8.21	9.63	7.21
Rasin's IXL Fertilizer		G	0.82	9	10	3
McLean	4449	F	1.30	8.88	10.46	4.84
Rasin's National Crop Compound		G	0.82	8	9	4
Homer	6349	F	1.01	8.74	10.20	4.42
Rasin's Nitro Top Dresser		G	8.23	4	5	4
Angelica	5966	F	7.94	4.28	4.86	4.06
Rasin's Pure Raw Bone		G	3.70	——	20.60	——
Delanson	5128	F	3.64	——	21.68	——
Rasin's Special Fish and Potash Mixture		G	3.29	6	7	10
Linwood	6459	F	2.83	7	8.79	8.87
Rasin's Special for Vines and Vegetables		G	0.82	8	9	8
Angelica	5967	F	0.80	7.92	9.46	8.36
Rasin's United Grain Grower		G	0.82	8	9	2
Sherburne	6400	F	1.00	8.51	9.95	1.90
Rasin's Vegetable Special		G	1.65	8	9	10
Homer	6348	F	1.88	8.35	9.95	10.84

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
RASIN MONUMENTAL CO., BALTIMORE, MD. (*concluded*)						
Rasin's Wheat and Truck Mixture		G*	——	10	11	8
Penn Yan	4921	F*	——	10.86	11.80	8.60
Rasin's XXX Fertilizer		G	1.65	8	9	5
East Berne	5249	F	1.84	8.02	9.18	6.12
READING BONE FERTILIZER CO., READING, PA.						
Alkaline Phosphate and Potash		G	——	8	9	5
Hamburg	5028	F	——	8.77	9.05	5.20
Farmer's Tankage and Potash for Corn, Grain and Grass		G	0.82	8	9	4
Gowanda	5069	F	0.88	8.34	9.24	4.10
Gilt Edge Potato and Tobacco Grower		G	1.64	7	8	10
Gowanda	5068	F	1.66	7.73	8.93	9.56
Muriate of Potash		G	——	——	——	50
Hamburg	5032	F	——	——	——	49.44
Nitrate of Soda		G	14.80	——	——	——
Hamburg	5031	F	14.98	——	——	——
Reading All Crop Special		G	1.64	7	8	5
Hamburg	5026	F	1.56	7.65	8.67	6.16
Reading Prize Winner		G	2.47	9	10	12
Gowanda	5067	F	2.43	8.60	10.14	12.48
Reading Special Potato and Tobacco Manure		G	0.82	6	7	7
Marilla	5911	F	0.85	6.13	7.33	6.94
Reading's Ten and Eight		G	——	10	11	8
Honeoye Falls	6009	F	——	10.20	10.78	7.64
Tobacco and Truck Special		G	2.47	6	7	6
Hamburg	5027	F	2.33	7.11	8.03	6.24
Truck, Fruit Tree, Vine, Potato and Tobacco Grower		G	3.29	8	9	7
Hamburg	5029	F	3.24	8.81	9.63	7.42

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
REEVES CO., R. C., NEW YORK, N. Y.						
Reeve's Phospho-Peruvian Guano		G*	2.50	9	10	4.25
New York	6120	F*	2.47	9.24	10.10	4.68
REICHARD, ROBERT A., Allentown, Pa.						
Lehigh Potato Manure		G	1.64	8	10	10
Johnsons	5684	F	1.63	8.57	9.05	10.32
ROGERS & HUBBARD CO., THE, PORTLAND, CONN.						
Hubbard's Bone Base Complete Phosphate		G	1.50	7	8	5
Fallsburg	6410	F	1.70	8.45	10.07	5.30
Hubbard's Bone Base Fertilizer for Seeding Down and Fruit		G	2.20	6.50	16	12
East Chatham	4822	F	2.39	8.66	17.26	13.06
Hubbard's Bone Base New Market Garden Phosphate		G	2	6	7	10
Sharon Springs	5108	F	2.15	7.46	9.50	9.25
Hubbard's Bone Base Oats and Top Dressing		G	8.50	4.50	8	8
East Chatham	4821	F	7.91	6.27	9.09	9.10
Hubbard's Bone Base Potato Phosphate		G	2	9	10	5
Sharon Springs	5214	F	2.24	9.68	10.52	5.18
Hubbard's Bone Base Soluble Corn and General Crops Manure		G	2.50	6	8	8
East Chatham	4823	F	2.67	6.47	7.83	8.04
Hubbard's Bone Base Soluble Tobacco Manure		G	5	7	10	10
East Chatham	4824	F	5.12	7.74	11.22	9.92
ROYSTER GUANO CO., F. S., BALTIMORE, MD.						
Nitrate of Soda		G	15	——	——	——
Delhi	3650	F	15.42	——	——	——
Nitrate of Soda		G	15	——	——	——
Caywood	6533	F	15.37	——	——	——

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
Royster Guano Co., F. S., Baltimore, Md. (*continued*)						
Royster's Ammoniated Potash Compound		G*	0.82	9	9.50	7
Batavia	5383	F*	1.09	9.55	10.27	8.40
Royster's Big Yield Potato Producer		G	1.65	5	5.50	10
Richfield Springs	4239	F	1.91	6.26	7.20	10.06
Royster's Big Yield Potato Producer		G	1.65	5	5.50	10
Lorraine	5157	F	2.27	7.83	9.03	8.96
Royster's Bumper Crop Phosphate		G	——	8	8.50	5
Fultonville	5592	F	——	9.12	9.50	5.92
Royster's Challenge Complete Compound		G	1.65	8	8.50	6
Canaseraga	4530	F	1.71	8.56	9.56	6
Royster's Champion Crop Compound		G	1.65	8	8.50	4
Fort Ann	5302	F	1.66	8.58	9.12	4.24
Royster's Complete Potato Manure		G	3.29	6	6.50	10
Delhi	3648	F	3.38	7.08	8.22	10.58
Royster's Corn and Hop Special Fertilizer		G	2.06	8	8.50	3
Richfield Springs	5554	F	2.10	9.24	9.88	3.24
Royster's Fish, Flesh and Fowl		G	1.65	8	8.50	3
Batavia	5382	F	1.80	8.78	9.56	3.38
Royster's 14% Acid Phosphate		G	——	14	14.50	——
Richfield Springs	4243	F	——	14.87	15.11	——
Royster's General Crop Fertilizer		G	0.82	8	8.50	5
Lorraine	5163	F	1.10	8.56	9.44	5.08
Royster's Gold Seal Potato and Cabbage Special		G	1.65	8	8.50	10
Delhi	3644	F	1.67	8.64	9.56	10.74

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
ROYSTER GUANO CO., F. S., BALTIMORE, MD. (*continued*)						
Royster's Harvest King Fertilizer		G*	1.65	8	8.50	2
Clyde	4758	F*	1.93	8.99	9.37	3.02
Royster's High Grade Acid Phosphate		G	——	16	16.50	——
Cobleskill	5123	F	——	17.09	17.47	——
Royster's High Grade Potato Grower		G	2.47	6	6.50	10
Canaseraga	4528	F	2.35	6.98	8.16	9.63
Royster's High Grade Potash Mixture		G	——	10	10.50	10
Delhi	3647	F	——	10.94	11.22	10.14
Royster's High Grade Potash Mixture		G	——	10	10.50	10
Lorraine	5161	F	——	10.85	11.45	10.03
Royster's Imperial Formula		G	0.82	8	8.50	4
Lorraine	5160	F	0.89	7.98	8.80	5.69
Royster's Peerless Grain and Grass Grower		G	——	10.10	10.50	2
Lorraine	5159	F	——	10.94	11.22	2.48
Royster's Peerless Grain and Grass Grower		G	——	10	10.50	2
Bath	6552	F	——	10.66	10.97	2.18
Royster's Practical Truck Guano		G	2.47	8	8.50	6
Mellinville	4819	F	2.80	8.80	9.58	7.46
Royster's Prolific Potato Producer		G	1.23	6	6.50	5
Sterlingville	5708	F	1.40	6.96	7.78	5.32
Royster's Pure Raw Bone Meal		G	3.70	——	21.50	——
Peconic	5520	F	4.17	——	22.32	——
Royster's Royal Special Potato Guano		G	4.11	7	7.50	7
Riverhead	5497	F	4.16	8.16	8.76	7.18

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer: Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
Royster Guano Co., F. S., Baltimore, Md. (*concluded*)						
Royster's Seeding Down Special Fertilizer		G*	0.82	9	9.50	3
Delhi	3645	F*	1.06	10.16	10.78	4.02
Royster's Special Celery and Onion Guano		G	3.29	8	8.50	12
Berlin	5674	F	3.31	8.60	9.18	12.78
Royster's Special Corn and Tomato Guano		G	1.65	7	7.50	5
Lorraine	5158	F	2.02	7.88	8.96	4.92
Royster's Special Corn and Tomato Guano		G	1.65	7	7.50	5
Sterlingville	5709	F	1.71	6.95	7.95	6.57
Royster's Special Fruit and Crop Grower		G	——	10	10.50	8
Lorraine	5162	F	——	10.75	11.23	8.02
Royster's Superior Potash Mixture		G	——	12	12.50	5
Perry	3196	F	——	12.89	13.33	4.97
Royster's Truckers Favorite		G	4.94	8	8.50	5
Floral Park	5452	F	4.64	9.20	9.56	6
Royster's Universal Truck Fertilizer		G	3.29	8	8.50	7
Unadilla	5773	F	2.82	9.11	9.54	7
Royster's Wheat, Oats and Barley Fertilizer		G	0.82	8	8.50	2
Perry	3195	F	0.92	8.19	8.99	1.90
Sanderson Fertilizer & Chemical Co., New Haven, Conn.						
Nitrate of Soda		G	15	——	——	——
Hicksville	5418	F	15.36	——	——	——
Riverhead Town Agri. Society Fertilizer 1913, Formula No. 2		G	4.94	8	——	5
Riverhead	5478	F	4.97	9.02	11.06	5.14
Sanderson's Special Potato Manure		G	3.30	7	8	7
Hicksville	5417	F	3.32	8.90	9.50	7.48

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
SCHAAL-SHELDON FERTILIZER CO., BUFFALO, N. Y.						
Complete Fertilizer with Extra Potash		G*	1.65	8	9	10
Eden Center	5074	F*	1.71	8.53	9.31	10.18
Dissolved Phosphate with Extra Potash		G	——	10	11	4
Fredonia	5933	F	——	10.43	11.03	3.98
Farmers' Favorite		G	0.82	8	9	2
Kennedy	5091	F	1.01	8.10	9.50	2.48
Fruit and Vine Fertilizer		G	2.47	6	7	10
Springville	5941	F	2.50	6.10	7.82	9.80
Grass and Grain Fertilizer		G	1.23	8	10	7
Eden Center	5073	F	1.34	8.38	9.18	7.36
Guano		G	0.82	8	9	4
Kennedy	5092	F	1.04	8.25	9.65	3.99
High Grade Ground Bone		G	3.29	——	20.59	——
Kennedy	5093	F	3.24	——	23.84	——
New York Trucker		G	3.29	8	9	7
Pavilion	6452	F	3.38	7.20	9.50	7.02
Schaal's Corn and Potato		G	1.65	8	9	4
Eden Center	5076	F	1.90	8.83	9.63	4.18
Schaal's Standard		G	1.65	8	9	2
Boston	5937	F	1.63	8.28	10.20	2.66
Superior		G	0.82	7	8	9
Eden Center	5075	F	1.03	6.78	8.42	9.22
Ten and Eight		G	——	10	11	8
Lawton	5923	F	——	9.67	10.06	6.72
SHAFER CO., PERRY C., BROCKPORT, N. Y.						
Shafer's Special Fertilizer		G	2.06	8	9	5
Brockport	5357	F	2.31	7.71	8.73	5.20

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
Shay Fertilizer Co., The C. M., Groton, Conn.						
Fine Ground Bone		G*	2.46	——	30	——
Orient	5526	F*	2.59	——	23.08	——
Shay's Potato Manure		G	3.29	8	8	7
Orient	5523	F	3.16	7.32	9.12	6.98
Shoemaker & Co., Ltd., M. L., Philadelphia, Pa.						
Swift-Sure Bone Meal		G	4.53	——	20	——
Southampton	5534	F	4.21	——	21.16	——
Swift-Sure Guano for Truck, Corn and Onions		G	1.65	8	——	5
Southampton	5533	F	1.85	9.78	11.16	6.08
Stappenbeck & Sons, H., Utica, N. Y.						
Animal Bone and Potash		G	2	8	16	3.50
Cazenovia	5836	F	2.40	12.04	19.64	4.84
Stevens, Chas., Napanee, Ontario						
"Beaver Brand" Canada Unleached Hardwood Ashes		G	——	——	1.50	4
Syracuse	6172	F	——	——	1.70	3.66
Stockwell Co., J. W., Fillmore, N. Y.						
Stockwell Co's Home Mixed 4–8–8 Fertilizer		G	3.29	8	——	8
Fillmore	5970	F	3.24	8.30	8.58	8.86
Stockwell Co's Home Mixed 1–10–10 Fertilizer		G	0.82	10	——	10
Fillmore	5971	F	0.83	10.54	10.83	10.68
Stockwell Co's Home Mixed 2–8–10 Fertilizer		G	1.65	8	——	10
Fillmore	5969	F	1.68	7.93	8.82	10.54
Stumpp & Walter Co., New York, N. Y.						
Emerald Lawn Dressing		G	3	5	7	6
New York	5548	F	3.65	6.62	8.22	6.50
S. & W. Co's Bone Fertilizer		G	3	——	20	——
New York	5549	F	3.85	——	25.38	——

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
SWIFT & COMPANY, CHICAGO, ILL.						
Nitrate of Soda		G*	14.77	——	——	——
Kennedy	5090	F*	15.50	——	——	——
Nitrate of Soda		G	15.22	——	——	——
Hicksville	5441	F	15.27	——	——	——
Swift's Animal Bone Fertilizer Young Bros. Formula No. 1		G	4.94	8	——	5
Aquebogue	5494	F	4.82	8.68	9.24	5.22
Swift's Diamond B Fertilizer		G	2.47	8	——	5
Glen Cove	5404	F	2.41	8.33	8.99	5.66
Swift's Early Potato and Vegetable Grower		G	3.29	6	——	10
Glen Cove	5410	F	3.22	6.48	6.76	10.18
Swift's Grain Fertilizer		G	0.82	8	——	2
Cherry Valley	5229	F	0.93	8.16	8.61	1.92
Swift's Kainit		G	——	——	——	12
Otego	5778	F	——	——	——	11.44
Swift's Onion, Potato, Tobacco		G	1.65	8	——	7
Horseheads	4933	F	1.52	8.80	9.12	7.16
Swift's Pulverized Sheep Manure		G	2.50	0.50	1.50	1.50
Gowanda	5925	F	2	——	1.65	2.20
Swift's Pure Bone Meal		G	2.47	——	24	——
Eden Center	5071	F	2.45	——	24.94	——
Swift's Pure Bone Meal		G	2.47	——	24	——
Glen Cove	5405	F	2.46	——	26.28	——
Swift's Pure Corn and Wheat Grower		G	0.82	8	——	4
Savona	4948	F	0.95	7.90	8.48	3.70
Swift's Pure Diamond B Fertilizer		G	2.47	8	9	5
Kennedy	5088	F	2.19	7.82	9.24	7.26
Swift's Pure Diamond C Fertilizer		G	1.65	8	9	4
Horseheads	4935	F	1.65	8.08	8.48	3.79

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer: Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
Swift & Company, Chicago, Ill. (*continued*)						
Swift's Pure Diamond C Fertilizer		G*	1.65	8	——	4
Delhi	6401	F*	1.50	8.15	8.61	3.92
Swift's Pure Diamond C Fertilizer		G	1.65	8	——	4
Romulus	6541	F	1.57	8.35	8.67	4.30
Swift's Pure Diamond E Fertilizer		G	3.29	8	——	7
Cortland	6339	F	3.38	7.52	8.16	7.98
Swift's Pure Diamond F Fertilizer		G	——	8	——	3
Savona	4946	F	——	8.29	8.61	3.24
Swift's Pure Diamond G Fertilizer		G	——	10	——	8
Hamden	3635	F	——	10.20	10.90	8.02
Swift's Pure Diamond G Fertilizer		G	——	10	——	8
Horseheads	4934	F	——	10.02	10.46	8.04
Swift's Pure Diamond G Fertilizer		G	——	10	——	8
Cherry Valley	5231	F	——	10.01	10.62	7.61
Swift's Pure Diamond G Fertilizer		G	——	10	——	8
Romulus	6542	F	——	10.60	11.54	7.94
Swift's Pure Dissolved Animal Bone and Potash		G	1.23	13	18	4
Medina	5915	F	1.34	16.04	19.64	3.23
Swift's Pure Early Potato and Vegetable Grower		G	3.29	6	7	10
Kennedy	5089	F	2.83	6.43	7.89	9.20
Swift's Pure Garden City Acid Phosphate		G	——	14	——	——
De Ruyter	6391	F	——	13.88	14.16	——
Swift's Pure Grain Fertilizer 3–8–2		G	2.47	8	——	2
Altamont	5120	F	2.38	7.66	8.80	2.16
Swift's Pure High Grade Market Garden Manure		G	3.29	8	——	7
Valley Stream	5435	F	3.25	8.68	9.50	7.32

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
SWIFT & COMPANY, CHICAGO, ILL. (*concluded*)						
Swift's Pure Potato, Celery and Onion		G*	0.82	5	——	10
Delhi	6403	F*	0.85	4.93	5.23	9.36
Swift's Pure Red Steer		G	1.65	8	——	2
Cherry Valley	5230	F	1.64	8.58	8.86	1.96
Swift's Pure Screened Hard Wood Ashes		G	——	——	——	6
Hamlin	6017	F	——	——	——	5.52
Swift's Pure Special Alkaline Mixture		G	——	10	——	10
Delhi	3643	F	——	9.92	10.30	10.15
Swift's Pure Special High Grade Acid Phosphate		G	——	16	——	——
Union	6160	F	——	16.83	17.03	——
Swift's Pure Special Phosphate and Potash		G	——	10	——	2
Altamont	5117	F	——	10.39	11.29	2.14
Swift's Pure Superphosphate		G	1.65	8	9	2
Eden Center	5070	F	1.65	8.48	9.56	1.92
Swift's Pure Truck Grower		G	0.82	8	——	4
Cortland	6343	F	0.85	8.08	8.42	3.94
Swift's Special Potato Fertilizer		G	1.65	8	——	10
Herkimer	4231	F	1.62	8.23	8.61	9.34
Swift's Special Tobacco Fertilizer		G	4.50	3	——	5.50
Savona	4943	F	3.92	2.77	2.94	5.10
SYRACUSE RENDERING CO., SYRACUSE, N. Y.						
Animal Brand, A Complete Fertilizer		G	2.46	8	9	4
Waterville	5561	F	2.54	8.98	9.50	4.36
Syracuse Bone Meal for Cattle and Poultry		G	3.28	5	23	——
Syracuse	6174	F	3.48	11.20	21.94	——

*These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
Syracuse Rendering Co., Syracuse, N. Y. (*concluded*)						
Syracuse Ground Bone		G*	2.46	——	23	——
North Collins	5921	F*	2.61	——	25.88	——
Syracuse Gypsy Brand		G	——	10	11	8
Adams	5167	F	——	10.71	10.97	8.08
Syracuse Indian Brand for Corn and Wheat		G	1.64	8	9	4
Adams	5166	F	1.87	8.21	8.93	4.51
Syracuse Market Garden Manure		G	3.28	7	8	8
Port Dickinson	5867	F	3.70	8.17	9.69	8.90
Syracuse Onondaga Brand		G	0.82	8	9	4
Collins Center	5060	F	0.92	7.96	8.42	4.14
Syracuse Potato Manure		G	2.46	8	9	6
Waterville	5562	F	2.42	8.78	10.46	6.93
Syracuse Seneca Brand		G	1.24	8	9	4
Binghamton	5863	F	1.25	8.33	8.93	4.10
Syracuse Special for Celery, Cabbage and Potatoes		G	1.24	7	8	9
Adams	5168	F	1.31	6.83	7.68	9.35
Syracuse Superphosphate		G	0.82	7	8	2
Clarence	5906	F	1.07	7	7.52	2
Syracuse Superphosphate for Oats and Buckwheat		G	0.82	7	8	2
Cincinnatus	6377	F	1.04	7.14	7.73	2.24
Thomas & Son Co., I. P., Philadelphia, Pa.						
Farmers' Choice Phosphate		G	1.60	9.50	10	2
Wading River	5516	F	2.00	9.62	10.14	2.44
Pure Ground Bone		G	2.46	——	23	——
Easthampton	5535	F	2.68	——	23.46	——
S. C. Phosphate		G	——	14	14.50	——
Wading River	5518	F	——	15.97	16.07	——

*These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
			Nitrogen	Phosphoric acid		Potash
				Available	Total	
THOMAS & SON CO., I. P., PHILADELPHIA, PA. (*concluded*)						
Thomas' Long Island Special 4–8–7		G*	3.25	8	——	7
Southampton	5532	F*	3.47	7.63	7.97	7.90
Thomas' Truck and Potato Fertilizer		G	4.11	7	8	8
Easthampton	5536	F	3.89	7.74	8.16	8.26
Truckers High Grade Guano		G	3.29	7	8	7
Wading River	5517	F	3.30	7.35	7.97	7.26
THOMSON & SONS, LTD., WM., TWEED VINEYARD, CLOVENFORDS, SCOTLAND						
Thomson's Vine Plant and Vegetable Manure		G	3.25	7.50	——	5
New York	6103	F	3.68	9.16	12.32	5.96
THORBURN & CO., J. M., NEW YORK, N. Y.						
Thorburn's Complete Manure		G	2.47	6	7	6
New York	5544	F	2.57	6.43	7.71	6.16
Thorburn's Lawn Fertilizer		G	4.94	8	9	5
New York	5545	F	4.47	9.24	9.98	5.74
TUNNELL & CO., INC., F. W., PHILADELPHIA, PA.						
F. W. Tunnell & Co's Bone, Blood and Potash		G	4.12	8	9	7
Floral Park	5454	F	3.71	8.97	10.01	7.24
F. W. Tunnell & Co's New York Potato and Truck Manure		G	3.30	8	9	7
Floral Park	5453	F	3.32	7.15	7.75	7.04
TUTHILL, NAT. S., PROMISED LAND, N. Y.						
Southold Town Club Fertilizer, Wm. A. Fleet, Purchasing Agent 5–8–8		G	4.10	8	——	8
Southold	5521	F	4.03	7.75	7.97	8.16
Southold Town Club Fertilizer, Wm. A. Fleet, Purchasing Agent 6–8–5		G	4.92	8	——	5
Riverhead	5480	F	4.70	7.87	8.03	6.06

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
TUSCARORA FERTILIZER CO., BALTIMORE, MD.						
Animal Tankage		G*	7.41	——	6.87	——
Sheridan	5950	F*	7.39	——	7.46	——
High Grade Dried Blood		G	13.16	——	——	——
Sheridan	5949	F	13.03	——	——	——
Muriate of Potash		G	——	——	——	48
Sheridan	5951	F	——	——	——	47.33
Nitrate of Soda		G	14.81	——	——	——
Sheridan	5952	F	15.40	——	——	——
Nitrate of Soda		G	14.81	——	——	——
Blodgett Mills	6165	F	15.04	——	——	——
Tuscarora Acid Phosphate		G	——	14	14.50	——
Cincinnatus	6371	F	——	12.65	12.94	——
Tuscarora Animal Bone		G	2.47	——	22	——
Silver Creek	5948	F	2.67	——	23.18	——
Tuscarora Big 4 Four		G	1.65	7	7.50	4
Cincinnatus	6367	F	1.74	6.93	7.97	6.69
Tuscarora Crop Grower		G	0.82	8	8.50	2
Akron	5909	F	0.73	7.92	8.48	3.80
Tuscarora Fruit & Potato		G	1.65	8	8.50	10
Cincinnatus	6368	F	1.62	8.56	9.12	10.42
Tuscarora High Grade		G	——	10	10.50	8
Cincinnatus	6366	F	——	10.63	11.03	7.71
Tuscarora Phosphate and Potash		G	——	10	10.50	2
Cincinnatus	6370	F	——	9.68	10.08	2
Tuscarora Special Potato Grower		G	3.29	8	8.50	7
Silver Creek	5947	F	3.23	8.19	9.35	7.04
Tuscarora Standard		G	1.65	8	8.50	2
Cincinnatus	6369	F	1.60	8.08	9.44	3.90

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer			
				Phosphoric acid		
			Nitrogen	Available	Total	Potash
TUSCARORA FERTILIZER CO., BALTIMORE, MD. (*concluded*)						
Tuscarora Trucker's Special		G*	3.29	6	6.50	10
Silver Creek	5946	F*	2.99	6	6.72	9.92
Tuscarora York State Special		G	0.82	8	8.50	4
Akron	5910	F	1.14	7.88	9.18	5.20
TYGERT CO., J. E., PHILADELPHIA, PA.						
Tygert's Special Potato and Tobacco Fertilizer		G	3.29	6	7	8
Hicksville	5442	F	3.45	6.59	7.71	8.12
UNITED STATES FERTILIZER CO., THE, BALTIMORE, MD.						
Farm Bell Acid Phosphate		G	——	14	15	——
Almond	5965	F	——	15.57	15.85	——
Farm Bell Animal Ammoniated		G	1.65	8	9	5
Stanley	6001	F	1.64	8.90	9.50	5.04
Farm Bell Celery Compound		G	3.28	8	9	12
Williamson	6019	F	3.14	9.17	9.69	12.82
Farm Bell Excelsior Guano		G	3.28	8	9	7
Williamson	6020	F	3.22	9.60	10.20	6.76
Farm Bell Fruit and Grain Grower		G	——	10	11	8
Stanley	6002	F	——	10.49	11.03	8.08
Farm Bell Fruit and Potato Guano		G	1.65	8	9	10
Cameron Mills	6466	F	1.74	8.78	9.50	11.34
Farm Bell Meat and Potash Mixture		G	0.82	9	10	7
Stanley	6003	F	1.09	9.88	10.46	7.44
Farm Bell Pennant Winner		G	0.82	8	——	4
Rushville	6468	F	0.93	8.56	9.26	4.56
Farm Bell Phospho Potasso		G	——	12	13	5
Cameron Mills	6470	F	——	11.96	12.18	4.70
Farm Bell Potato Special		G	3.28	6	7	10
Burns	6469	F	2.97	7.32	7.92	9.88

* These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Pounds in 100 Pounds of Fertilizer: Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
United States Fertilizer Co., The, Baltimore, Md. (*concluded*)						
Farm Bell Wheat Oat Corn Special		G*	0.82	8	9	6
Williamson	6021	F*	0.95	8.98	9.76	6.18
Vaughan's Seed Store, New York, N. Y.						
Vaughan's Lawn and Garden		G	2.88	8	——	4
New York	6101	F	2.57	8.45	9.63	4.34
Vaughan's Rams Head Brand Pulverized Sheep Manure		G	2	——	1.20	1
New Rochelle	5623	F	2.38	——	1.97	1.82
Vaughan's Rams Head Brand Pulverized Sheep Manure		G	2	1	1.20	1
New York	6118	F	1.99	1.18	1.26	1.66
Vaughan's Rose Grower Bone Meal		G	3.70	——	22	——
New York	5550	F	4.30	——	22.32	——
Virginia Carolina Chemical Co., New York, N. Y.						
Nitrate of Soda		G	14.82	——	——	——
Bridgehampton	5530	F	15.20	——	——	——
V. C. C. Co's Animal Ammoniated Guano		G	0.82	8	9	4
Marathon	6385	F	1.09	9.77	10.01	4.26
V. C. C. Co's Beef, Blood and Bone B. B. B.		G	3.29	8	9	7
Valley Stream	5433	F	3.26	9.42	10.58	7.62
V. C. C. Co's Champion Corn and Grain Grower		G	1.65	10	11	5
Freeport	5443	F	1.82	10.25	11.35	6.10
V. C. C. Co's Diamond Ammoniated Superphosphate		G	2.47	7	8	5
Marathon	6384	F	2.67	7.67	8.67	6.24
V. C. C. Co's Early Truckers Special		G	4.94	8	9	5
Riverhead	5479	F	4.85	8.83	9.63	6.36

*These letters indicate, respectively, Guaranted and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER			
			Nitrogen	Phosphoric acid: Available	Phosphoric acid: Total	Potash
VIRGINIA CAROLINA CHEMICAL CO., NEW YORK, N. Y. (*concluded*)						
V. C. C. Co's Fruit and Vine Fertilizer		G*	0.82	8	9	8
White Plains	5619	F*	0.91	8.82	9.87	8
V. C. C. Co's General Crop Grower		G	0.82	8	9	5
Freeport	5445	F	1.04	8.56	9.56	5.86
V. C. C. Co's Good Luck Fertilizer		G	0.82	9	10	2
Oxford	5817	F	1.26	9.55	10.71	2.76
V. C. C. Co's Indian Brand for Potatoes and General Use		G	2.47	6	7	10
Sherburne	5803	F	2.69	5.65	7.01	9.94
V. C. C. Co's Little Giant Fertilizer		G	——	9	10	3
Freeport	5444	F	——	9.50	10.46	3.76
V. C. C. Co's Monogram Complete Compound		G	1.65	8	——	4
Hempstead	5460	F	1.68	8.36	9.56	3.98
V. C. C. Co's National Alkaline Phosphate		G	——	10	11	8
Oxford	5818	F	——	10.87	11.99	8.30
V. C. C. Co's Owl Brand Potato and Truck Fertilizer		G	1.65	8	9	10
Marathon	6386	F	1.68	8.95	10.05	9.04
V. C. C. Co's Soluble Guano		G	1.65	8	9	2
Bridgehampton	5531	F	1.72	8.46	9.76	3.10
V. C. C. Co's Star Brand Potato and Vegetable Compound		G	3.29	6	7	10
White Plains	5618	F	3.44	6.97	8.03	10.26
V. C. C. Co's Tip Top Top Dresser		G	5.76	5	6	5
Stanfordville	4828	F	4.87	5.71	6.36	6.19
V. C. C. Co's 20th Century Potato Manure		G	4.12	8	9	8
Calverton	5510	F	4.27	8.60	9.54	8.82

*These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER			
			Nitrogen	Phosphoric acid Available	Phosphoric acid Total	Potash
WEEBER & DON, NEW YORK, N. Y.						
Weeber & Don's Lawn Invigorator		G*	2.47	——	3.50	2.50
New York	6119	F*	2.56	——	4.33	2.81
WHANN CO., W. E., PHILADELPHIA, PA.						
Whann's Chester Valley Fish and Potash Fertilizer		G	1.48	8	9	5
Babylon	5542	F	1.66	7.84	9.50	4.58
WILCOX FERTILIZER CO., THE, MYSTIC, CONN.						
Wilcox Cauliflower Fertilizer		G	4.11	6	7	5
Amagansett	5537	F	4.01	6.84	8.16	6.20
Wilcox Dry Ground Acidulated Fish		G	7.81	4	6	——
Orient	5524	F	7.91	5.01	5.67	——
Wilcox Fish and Potash		G	2.46	5	6	3
Baiting Hollow	5504	F	2.81	5.40	7.20	3.70
Wilcox Potato, Onion and Vegetable Phosphate		G	3.30	8	9	7
Mattituck	5511	F	3.46	8.65	9.31	7.06
Wilcox Pure Ground Bone		G	2.46	——	22	——
Greenport	5528	F	2.73	——	22.70	——

*These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

LIME (CALCIUM) COMPOUNDS

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		Calcium oxide (CaO)	Equal to calcium (Ca)	Magnesium oxide (MgO)	Equal to magnesium (Mg)
AMERICAN AGRICULTURAL CHEMICAL CO., THE, NEW YORK, N. Y.						
Fine Ground Nova Scotia Plaster		G*	——	——	——	——
Hudson Falls	5313	F*	37.42	26.75	——	——
AMERICAN LIME & STONE CO., TYRONE, PA.						
Hydra-Oxide of Lime		G	66.75	47.70	——	——
Portville	5953	F	68.99	49.30	2.38	1.44
BAKER CO., J. E., BAINBRIDGE, PA.						
Victor Ground Limestone		G	47	33.50	——	——
Nunda	6457	F	49.63	35.45	4.48	2.70
BALLARD CO., J. W., BINGHAMTON, N. Y.						
Ground Limestone		G	——	——	——	——
Collins	5053	F	51.92	37.10	2.68	1.62
Ground Limestone		G	50	35.70	——	——
Binghamton	6364	F	35.89	25.65	11.19	6.75
CALEDONIA CHEMICAL CO., CALEDONIA, N. Y.						
Better Farming Lime		G	50	35.70	——	——
Hudson	4826	F	49.33	35.25	1.85	1.12
CONLEY STONE CO., F. E., UTICA, N. Y.						
Raw Ground Lime		G	51.50	36.80	——	——
Guilford	5828	F	51.51	36.80	2.12	1.98
CORSON, G. & W. H., PLYMOUTH MEETING, PA.						
Corson's Prepared Lime (Hydrated)		G	42	30	——	——
Floral Park	5457	F	41.49	29.75	30.57	18.43
DUTCHESS COUNTY LIME CO., DOVER PLAINS, N. Y.						
Hydra-Oxide of Lime		G	37	26.45	——	——
Dover Plains	4813	F	42.17	30.10	31.99	19.30

*These letters indicate, respectively, Guaranteed and Found.

Analyses of Fertilizers Collected in New York State in Spring and Summer of 1914 (*continued*)

Lime (Calcium) Compounds (*continued*)

Name and Address of Manufacturer or Jobber; Brand or Trade Name; and Locality Where Sample was Taken	Number		Calcium oxide (CaO)	Equal to calcium (Ca)	Magnesium oxide (MgO)	Equal to magnesium (Mg)
Edison Portland Cement Co., Stewartsville, N. J.						
Edison Pulverized Limestone		G*	50	35.70	——	——
Penn Yan	4915	F*	51.92	37.10	3.06	1.85
Farnam Cheshire Lime Co., Farnams, Mass.						
Farnam Cheshire Lime Co's Agricultural Lime		G	60	43	——	——
White Plains	5620	F	91.81	65.55	——	——
Genesee Lime Co., Honeoye Falls, N. Y.						
Genesee Hydrate Hydrated Lime		G	65	46.40	——	——
Irondequoit	5379	F	70.83	50.60	2.60	1.56
Haserot Canneries Co., The, Cleveland, O.						
Horsehead Lime		G	54.72	39.10	——	——
Dayton	5926	F	45.22	32.30	2.12	1.27
International Agricultural Corporation, Caledonia Marl Branch, Caledonia, N. Y.						
Lime Carbonate		G	50	35.70	——	——
Port Crane	6395	F	49.38	35.30	1.44	0.86
Kelley Island Lime & Transport Co., The, Cleveland, O.						
Tiger Brand Agricultural Limestone		G	48	34.30	——	——
Hammondsport	4937	F	42.87	30.65	9.42	5.65
Tiger Brand Hydrated Agricultural Lime		G	54	38.60	——	——
Portville	5954	F	57.83	41.30	21.21	12.80
Le Roy Lime Works & Stone Quarries, Le Roy, N. Y.						
Le Roy Agricultural Lime		G	——	——	——	——
Le Roy	6039	F	75.90	54.20	2.99	1.80

* These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914 (*continued*)

LIME (CALCIUM) COMPOUNDS (*continued*)

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		Calcium oxide (CaO)	Equal to calcium (Ca)	Magnesium oxide (MgO)	Equal to magnesium (Mg)
OHIO & WESTERN LIME CO., THE, HUNTINGTON, IND.						
Agricultural Lime		G*	54.46	38.90	——	——
Cherry Creek	5086	F*	58.07	41.50	39.45	23.80
ROCKLAND & ROCKPORT LIME CO., ROCKLAND, ME.						
R. R. Land Lime		G	60	43	——	——
Hicksville	5459	F	60.53	43.20	3.48	2.10
SECURITY CEMENT & LIME CO., BERKELEY, W. Va.						
Berkeley Ground Limestone		G	——	——	——	——
Wellsville	5962	F	53.64	38.30	2.42	1.45
Berkeley Hydrated Lime		G	70	50	——	——
Belfast	5968	F	69.24	49.44	2.09	1.25
SOLVAY PROCESS CO., THE, Syracuse, N. Y.		G	60	43	——	——
Solvay Land Lime						
Blodgett Mills	6381	F	66.74	47.65	4.08	2.45
STANDARD LIME & STONE CO., THE, BUCKEYSTOWN, MD.						
Ground Lime		G	90	64	——	——
Calverton	5508	F	86.44	61.75	2.77	1.67
Standard Ground Limestone		G	50	35.70	——	——
Collins	5924	F	53.95	38.50	——	——
WARNER COMPANY, CHAS., WILMINGTON, DEL.						
Cedar Hollow Limoid		G	47	33.50	——	——
Cohocton	4925	F	46.73	33.40	34.69	22.92

*These letters indicate, respectively, Guaranteed and Found.

ANALYSES OF FERTILIZERS COLLECTED IN NEW YORK STATE IN SPRING AND SUMMER OF 1914.

MIXTURES CONTAINING COMPOUNDS OF LIME (CALCIUM), PHOSPHORIC ACID AND POTASH.

NAME AND ADDRESS OF MANUFACTURER OR JOBBER; BRAND OR TRADE NAME; AND LOCALITY WHERE SAMPLE WAS TAKEN	Number		POUNDS IN 100 POUNDS OF FERTILIZER: Phosphoric acid, Available	Phosphoric acid, Total	Potash	Calcium oxide (CaO)	Equal to calcium (Ca)	Magnesium oxide
CALEDONIA CHEMICAL CO., THE, CALEDONIA, N. Y.								
Wood Ashes Substitute		G*	1.50	2.50	5.50	35	25	———
Caledonia	6040	F*	2.85	2.93	5	40.44	28.90	———
CONLEY LIME & FERTILIZER CO., F. E., UTICA, N. Y.								
Eureka		G	———	8	5	40	28.60	———
Seneca Falls	6531	F	———	8.10	5.26	41.06	29.30	———
CORSON, G. & W. H., PLYMOUTH MEETING, PA.								
Corson's Prepared Lime and Potash		G	———	———	3	32	22.90	———
Apalachin	5868	F	———	———	4.30	29.22	20.90	23.62
INTERNATIONAL AGRICULTURAL CORPORATION, CALEDONIA MARL BRANCH, CALEDONIA, N. Y.								
Lime and Potash Mixture		G	1.50	2.50	5	40	28.60	———
Caledonia	6041	F	2.36	2.42	5.30	38.36	27.40	———

*These letters indicate, respectively, Guaranteed and Found.

APPENDIX.

I. Popular Editions of Station Bulletins.

II. Periodicals Received by the Station.

III. Meteorological Records.

POPULAR BULLETIN REPRINTS.

A NEW METHOD OF DETERMINING MILK QUALITY.*

F. H. HALL.

Microscopic bodies in milk. To the unaided eye, normal fresh cows' milk is a faintly yellowish, white liquid, apparently uniform throughout and simple in composition. Probably most of its consumers realize, however, that milk is more complex in make-up than it appears at first view, since they see fat rise to the surface as cream or find the casein coagulating after longer keeping. Yet few milk drinkers appreciate the great complexity in composition of this common article of diet, or know how many and how delicate means and methods must be used by scientists to identify the varied components of milk and to trace their intimate relationships as these affect the handling of milk and the making of other dairy products.

Fundamental study of milk is very essential, for apparently slight variations in the relationships of its constituents may greatly affect its value or even change it from a most wholesome food to a menace to health or to an actual poison.

Many of these studies may be left to the chemist, for he must determine the ultimate composition of all the milk constituents; and some of them he, only, can find, since they are in solution and therefore beyond the range of vision, even if aided by the most powerful microscope.

But milk contains, ordinarily, three classes of bodies, or under some conditions four, which can be brought into view by the microscope; and two of these classes of microscopic objects — the fat globules and the bacteria — have most intimate relations to the value and wholesomeness of milk; and the third class — cells and cell fragments — may be indicative of sanitary quality. Casein belongs in the "possible" fourth class referred to, for the minute particles of this colloid, or jelly-like substance, are only just beyond the power of the compound microscope. They are revealed by "ultra-microscopic" methods.

* Reprint of Popular Edition of Bulletins Nos. 373 and 380; for Bulletins see pp. 79 and 117.

Fat globules in milk studies. First of the bodies that may be seen when milk is properly exposed under the compound microscope are the fat globules. These are normal secretions of the udder and form an essential, though varying, proportion of all milk. Milk fat is very highly prized in human dietaries; so that the quantity of fat globules present in milk has come to serve as an index to its quality. Their amount can, however, be easily and accurately determined by a chemical method, the Babcock test; and microscopic study of them is not now considered so essential as at one time. Such study was very useful in early work on milk, in establishing the nature of these globules, and is still helpful in working out certain problems, like those of churning. In the most valuable microscopic work with milk, though, the fat globules are a detriment; since they are comparatively large and cover or obscure the other microscopic objects it is desired to study. Accordingly, in such work the fat must be dissolved. This is one step in a new method of microscopic examination of milk now in use at the Station, whereby the other two classes of minute objects are made to stand out clearly in the field of vision.

Cells in milk. Of these two classes, the cells should properly be placed first since they are, like the fat globules, normal constituents of all milk and are derived from the udder. These cells are discharged at all times in varying numbers. The fluctuations may or may not indicate diseased or abnormal conditions in the udder, therefore the changes in number may become an index to the sanitary quality of the milk.

Bacteria in milk. Though placed third among the microscopic bodies found in milk, because they are not normal constituents of it — are not produced by the udder but find their way into the milk after it is secreted — bacteria should really be considered first, for they are, without doubt, most important of all, at least from a sanitary standpoint. Though not essential components of milk, bacteria are almost universally found in it, even in the udder, and they exert a more immediate and greater influence toward change than any of the normal milk constituents. They are living organisms and make milk both their food and the scene of most diverse vital activities; so that each type of bacterium may change the milk materially, either for good or for ill.

Prescott–Breed microscopic method of milk study. Because of the importance of microscopic bodies in milk and because these have, until recently, been most studied by indirect methods, there seems much promise in a new plan of attack, originated by Prof. Prescott, of the Massachusetts Institute of Technology, and Dr. Breed, now of this Station. This method has already been used in two extensive series of studies made at the Station.

In using this method a small, measured drop (.01 cubic centimeter) is taken directly from a well mixed sample of milk, spread over a definite area of a clean glass microscope slide, and dried by gentle heat. Duplicate " smears " are usually placed on each slide. When dry, the slides are placed in xylol (a colorless, liquid chemical derived from benzine), which dissolves the fat. They are next immersed in alcohol to harden, or " fix," the dried milk to the slide, then in methylene blue to stain the bacteria and cells. A final immersion in alcohol reduces the blue color somewhat, and brings the microscopic objects out distinctly on a light blue field.

The cells, cell fragments and bacteria may now be easily studied and counted under the microscope, the " fields " appearing somewhat as shown on the plates. No printed reproduction, however, can bring out the stained objects as they are revealed in the light-suffused smear on the glass slide.

By adjusting the tube of the microscope to a definite length and using the proper eye-piece, each field examined will have a definite area and will represent a fixed fraction of the whole smear and, therefore, of the sample and, finally, of the milk itself. Several fields are examined on each smear, and on one or more duplicates, and the average count of cells or bacteria is taken as representative of the milk from which the sample was drawn.

STUDY OF BACTERIA IN MILK BY THE MICROSCOPICAL METHOD.

How bacteria in milk have been studied.

It is believed by the investigators at this Station, that, for many purposes, the use of the compound microscope for counting bacteria in milk is a much better method than the one now in common use. The present method of study is an indirect one, and depends on the fact that bacteria are living organisms. It counts them, not as they are in the milk, but only after they have so increased in numbers that around each one, or around each invisible cluster of them, a " colony " has developed large enough to be seen by using a hand lens or even the unaided eye.

The " technique," or detailed scheme of operations, in this method requires the use of a sample of milk, drawn carefully so it shall fairly represent the larger quantity from which it comes, and dilution of this sample to separate the bacteria and make it possible for colonies to grow without overlapping and obscuring one another or being so numerous that it is difficult to count them.

A definite portion of this diluted sample is then mixed with a " nutrient medium " or food supply, which is a gelatinous, translucent, or almost transparent material, firm at ordinary temperatures but fluid when warmed. This must be made sterile by heat so that no bacteria or other living organisms shall be present except those coming from the milk sample. By thoroughly and repeatedly

shaking together the warmed liquid medium and the milk sample, the bacteria are distributed somewhat evenly. The mixture is then poured into a flat, circular, glass dish known as a "petri plate," and spread evenly over the entire area. Usually one or more duplicate plates are made from each sample, and the plates are placed in an incubator to favor the growth of the colonies about each bacterial center. The temperature of incubation must be quite carefully regulated, for some bacteria are very sensitive and will not grow unless all the conditions are right. After four or five days, usually, colonies will have developed, presumably about each germ or group of them, until they are large enough to be visible under a hand lens of small magnifying power. Many of the colonies can then be seen by the naked eye, but others will be of pin-point size or smaller. All the colonies are counted on the whole plate or a definite portion of it, and the number obtained multiplied by the proper factor to account for the separation of the sample and amount of dilution. The final figure is commonly spoken of as the number of bacteria in the milk. This is never literally true, as some of the colonies always develop, not from single bacteria, but from "clumps" or unseparated collections of them. Moreover, a count made from plates held at one temperature only does not show all the colonies that might develop; for certain bacteria, like those accustomed to life in the udder and the warmth of the animal body, will not grow at low temperatures. By exposing the plates to such temperatures for two days longer, additional colonies may be developed. The opposite condition may also occur, and bacteria be present in the milk that thrive only at temperatures lower than the one commonly used for incubation.

It will be seen from this condensed popular description, that the "plate" method of counting bacteria is complex and time-consuming; and it is dependable only in the hands of trained bacteriologists, equipped with elaborate and costly appliances.

Comparative advantages of the two methods.

Do the two methods give equally reliable information regarding the number of organisms in milk? This question will be discussed at some length later, for the number of bacteria present is an important index to the sanitary quality of market milk; but the two methods differ so materially on many other points that it is necessary to summarize briefly the advantages and disadvantages of each.

The microscopic method is simple, comparatively inexpensive, can be learned easily by any bright young man, and can be applied successfully by men who are not necessarily trained bacteriologists; it makes possible a report on the bacterial content of a sample of milk within a very few minutes; and it shows not only the numbers of bacteria, but also their forms. Through this feature of the method, certain types of bacteria thought to be especially important

in relation to health can be identified at once. The method also shows the number and kind of cells in the milk, some of which may indicate the sanitary quality of the milk. On the other hand, the samples used for direct microscopic work are very small, are somewhat difficult to measure accurately, and may not represent the milk quite so well as larger samples would do. It is believed, however, that the rapidity of the method makes it possible to duplicate samples so extensively that the small size need not interfere with the accuracy of the work. An important objection is, however, that all bacteria are counted, whether living and active at time of sampling, or already dead and harmless.

By the plate method no dead organisms are counted, since living germs alone can grow to visible colonies. The colonies on the plates present differences in habit of growth that are quite characteristic for certain types of bacteria and this makes identification of some of them possible. By using different culture media, also, the plate method may be used to prove the presence or absence of liquefying bacteria, which cause some undesirable forms of milk decomposition, or of acid-formers that sour the milk. If particular types or species of bacteria are desired for special study, the plate method must be used to allow selection, isolation and the making of " pure cultures." Against the plate method we must place the length of time required before the count can be made—two, five, or even seven days in some cases before we can be sure that colonies have developed about all possible centers. The expense for apparatus — sterilizers, incubators, etc.— and the outlay involved in securing proper conditions to prevent outside contamination is large with the plate method; and the manipulations are so delicate that only trained bacteriologists can do the work successfully. The hand lens used is not powerful enough to show the individual bacteria; and these can not be readily studied on petri plates under the compound microscope; hence the information secured from colony-growth is all that is immediately available.

Comparing the methods.

The numbers of organisms present, without special regard to the kinds, is the information usually sought in bacterial examination of market milk; and if the new method fails to give this information accurately, its other advantages must count for little.

To determine the fundamental reliability of the microscopic method as compared with the now standard plate method, counts were made by Mr. Brew, by both methods, in 450 samples of milk from several different sources. In the main these samples were from milk from four farms contributing to the supply of the city of Geneva.

The studies on the milk of these farms began with the taking of samples of the milk each morning for ten weeks, as it was brought from the farms to a central delivery station in the city. Samples

of the fresh, morning milk were taken each day from the milk of one farm, and of the night milk, delivered at the same time, for 60 days. Not quite so many samples were taken from the other farms; but the series made possible a detailed study of the daily variation and development of the bacterial condition of the milk in 225 samples.

The milk from 33 other farms contributing to the city supply was studied in less detail, not more than a week being given to any farm, and only five fields in any sample were counted under the microscope. The object in these more superficial studies was to make a general survey of the situation and to determine the efficiency of the microscopical method when used rapidly as it would be under commercial conditions.

Relative accuracy of the two methods.

The results of the counts showed little relationship between the figures secured by the two methods when only single samples were considered; but when series of samples are examined a relationship is shown. The count made under the microscope is almost invariably much higher than that shown on the plates and certainly represents the total number of individual bacteria more accurately than the plate count, the results in the latter case being invariably low because of clumps. Among the 450 samples examined only three showed more bacteria by the plate method than by the direct microscope count.

The relative differences between the two counts are greater when the bacteria are few in number. In samples of milk showing plate counts of 10,000 per cubic centimeter, the microscope showed approximately 44 times as many individual bacteria. A somewhat fairer basis for comparison, however, is to consider each "clump" of bacteria shown under the microscope as a unit only, since such a collection of germs would, on the plate of nutrient medium, develop only one colony, perhaps indistinguishable in any way from the colony surrounding a single isolated bacterium.

On this basis, the germ-poor milk referred to above showed only 17 times as many organisms in the sample under the microscope as on the petri plate. When the milk contained more bacteria — about 1,000,000 per cubic centimeter — the count under the microscope was only about 5 times as great as on the plates; or, if the clumps were considered as units only, the microscope count was slightly lower than the plate count.

We cannot say definitely as yet, why there are such great differences in the counts by the two methods; but the fact that there are differences is not at all surprising under the conditions that have already been explained; and does not discredit either the old or the new method. It is hoped by further work to secure a logical and satisfactory explanation.

In the rapid examination of the samples from the 33 farms, which were not studied in detail, only a few fields were examined on each smear and if very few or no bacteria appeared on these fields the milk was " passed " as of good sanitary quality. Is this a safe procedure? Of the 225 samples thus examined 60 were passed; and the plate counts of these 60 samples showed that 42 of them contained less than 50,000 bacteria per cubic centimeter, eight were between 50,000 and 100,000, eight more less than 200,000 and two above this figure. (One of these high counts was probably due to a contaminated plate.)

Among the 120 samples examined more closely, 101 would have been " passed " by the more rapid, commercial examination, of which only two showed more than 100,000 bacteria per unit. The average plate count of 161 samples where no bacteria would have appeared on examination of a few fields was 29,000 per cubic centimeter; that is, practically all of the milk was of good or excellent sanitary character.

In other words, it seems safe to assume that practically all samples passed by the microscope as having no bacteria present when several fields are examined would yield a plate count of less than 100,000 per cubic centimeter.

On the other hand, out of 450 samples examined there were 246 that gave plate counts below 100,000 per unit; and 67 of these gave microscope smears in which bacteria could be readily found. Thus the plate method passed 67 of the 246 samples as having less than 100,000 bacteria per cubic centimeter when the microscopic examination showed they had many more than this.

Considering both comparisons and assuming all of the bacteria to be active, we find the plate method passing 67 out of 246 samples as below a certain limit when the microscope count showed them to be above that limit — an apparent error of 23 per ct.; whereas the microscopical method passed erroneously only 9 or 10 of 60 samples cursorily examined, a 15 per ct. or 17 per ct. error, or two samples of 101 carefully examined — a two per ct. error. Thus when the microscope is used in this way it tests milk more severely and probably more accurately.

The comparison of the two methods has been made only on fresh, unpasteurized milk, and the conclusions reached must be understood as applying only to the use of the microscopical method in milk of that character. Whether this method can be made applicable in studies of milk from unknown sources, which may include some that has been pasteurized, future studies must determine. In such milk most of the bacteria are dead and presumably harmless; but these dead germs appear under the microscope for a time, at least.

Why and where use the new method?

This new method of determining the bacterial content of milk, by the use of the compound microscope to count the organisms in stained milk smears on glass slides, from its rapidity, inexpensiveness, simplicity, absence of delicate manipulations calling for high technical skill, and wide scope in identification, seems a very promising assistant in the examination of milk. It is hoped that this method, or some modification of it, can be made of practical use to the milk dealer, butter-maker and cheese-maker as a means of grading milk according to its bacterial condition. This should make it easier for the farmer to secure a better price for a high-grade milk than for a poorer grade.

CELLS IN MILK.

Presence of cells in milk not new fact.

It has been known for three-quarters of a century that the first milk of each lactation period, the colostrum, contains cells derived from the udder or, through it, from the blood. The belief was, however, that these cells soon cease to be discharged, and that few are present in normal milk. Recent studies, though, especially those made during the past fifteen years, have proved that cells in large numbers are found in all normal milk; and that in some cases, which have accordingly been considered abnormal or the result of udder infection or disease, the multitude of such bodies seen under the compound microscope has been so great as to be almost beyond count.

Methods of study.

Much attention has been given to the development of methods for making such studies; but many of those employed have been indirect and complex. Most of these methods have required the rapid whirling of the milk in a centrifuge to throw out the sediment; and the samples for microscopic examination were taken from this sediment —not from the milk itself. The new method of Prescott and Breed, however, proves that not all of the cells in the milk are collected in this centrifuge sediment; for the counts of cells made by this method are much larger than those made by any examination of samples from sediment. The new method is a direct one, as small samples of the milk itself are taken and the counts made from "smears" viewed under the microscope. Though devised for the study of cell content of milk, this dried-smear method appears to be of even greater value in bacteriological work, as already pointed out.

Why study cells?

Cells in milk have been held by many students to be abnormal constituents and therefore undesirable. The makers of milk clarifiers have counted as one of the valuable features of clarification the fact that this process removes many cells from the milk.

Some of the cells found in milk are leucocytes — the white blood corpuscles that are the active agents in destroying certain disease germs in the body; and after the first week or so of lactation, the presence of these leucocytes in the udder has been considered evidence that they were attracted there because disease germs were in the milk. It has been held, in particular, that there is a close relationship between the presence of large numbers of cells and of the germs that cause mastitis, or inflammation of the udder, a disease that results in "gargety" milk.

Boards of health in some large cities, and one National organization, have adopted, as a standard for normal milk, a cell content not exceeding 500,000 per unit (a cubic centimeter, or 18 to 20 drops); and would reject milk showing more cells than this as abnormal and unfit for human food.

It is therefore important that the dairy farmer should know what justification there is for the belief that cells in milk are detrimental in themselves or as indicators of abnormal conditions or disease in the udder that might make milk unwholesome.

Studies at the Station. The studies on the cell content of the milk of the Station herd were made by Dr. Breed before he became a member of the staff; but his appointment as Bacteriologist renders doubly appropriate the publication, in a Station bulletin, of the valuable data secured.

The three main purposes in this work and the extent of the investigations were as follows:

(1) To make a number of examinations of the milk of individual animals in order to determine the normal cell content of milk. For this part of the work from five to eight samples were examined from each of 21 cows in the Station herd, from 62 to 68 samples from each of four other cows in this herd, and one sample from each of 53 cows in a Guernsey herd belonging to Mr. Alfred G. Lewis of Geneva. In the summaries along this line data are also included relative to the cell content of the milk of two other herds previously studied by Dr. Breed and his associates, one at Meadville, Pa., of 41 cows, and one in Germany of 3 cows.

(2) To make detailed examinations of the milk of individual cows in the hope that some reason could be discovered for the known variations. These included studies on the effect on cell content of period of lactation, age of cows, udder troubles, etc. For part of this work two cows fresh in milk were used for one week and for three weeks, respectively; four cows, more advanced in lactation, for five weeks; and eighteen cows, near the end of lactation, for one or two milkings.

(3) To study the influence of the milking machine on the number of cells discharged in milk. In these tests six cows were used for about forty days in a detailed study of the effect of varying the vacuum; two cows were under observation for 8 or 9 days in testing

the effect of a change from hand milking to machine milking; and the remainder of the herd furnished 56 samples of hand-drawn milk and twice as many drawn by machine.

Normal milk rich in cells.

The investigation proves plainly that milk apparently normal in all respects, from healthy cows in all stages of lactation, milked by hand or by machine, contains large numbers of cells. The average for the Station herd was lower than that of any other herd examined but was still 439,000 per cubic centimeter; the Guernsey herd came next, with 895,000, the three German cows were third, with 932,000; and the Pennsylvania herd averaged over a million cells per cubic centimeter. These numbers are much greater than those reported by other investigators, owing to the greater severity of the method used. By the older methods many cells in centrifuged samples were lost in the cream or remained in the milk and therefore could not be counted in the sediment samples used. It will be noticed that the average number for each of these herds, except that of the Station, is above the limit fixed as an allowable maximum as a result of examinations made by the older methods.

The milk of nine goats in the Station flock was also examined, and gave astonishingly high cell counts, the average for these goats and two others previously studied being nearly seven and a half million cells per unit. As goat milk is used with great success in the nutrition of infants and invalids, it would seem that high cell counts can not be a reliable indication of poor sanitary quality.

Variations and fluctuations in cell counts.

The average obtained for the Station herd represents wide variations, not only in different cows but also in the same cow at different times and in separate quarters of the same udder at the same time. The greatest average number of cells occurs in colostral milk; but equally large numbers of cells are occasionally found in milk drawn at any time during the lactation period. Several very high cell counts have been obtained from the milk of cows nearing the end of lactation, and such high counts appear to be more common at this time than near the middle of the time in milk. The average counts for the latter half of the period, however, are not markedly higher than those for the earlier half. As the quantity of milk is less toward the end of lactation the whole number of cells discharged is lower than during the earlier part of the period.

Marked variations occur in the numbers of cells found in the milk from day to day; but the cause or causes of these fluctuations have not yet been discovered. There is uniformly a larger number of cells in the strippings than in milk previously drawn, but it was not possible to assign a cause for the increase in cell counts in the strippings. No constant relationship could be found between the counts for the first streams from the udder and those from samples taken later.

The four quarters of the udder act independently, so far as cell content is concerned, since the counts for the different quarters of one cow's udder may show as great variations as those from separate udders.

In the group of cows that gave high average cell counts were two cows that had recently aborted, two old cows and one that had suffered from udder troubles, which might appear to indicate that these cows sustain the common belief that the peculiarities mentioned are causes of profuse cell shedding. On the other hand, however, one cow in this high-count group possessed no characteristic that has ever been thought to have an influence in producing such counts; and the low-count group contained one cow that had recently had udder troubles and still had a hard lump between the front quarters, one cow that had aborted within five weeks of the time of testing, and one old cow.

Influence of milking machine and vacuums.

The milking machine has been thought a cause of increased cell content of milk; as it was believed that the use of unusually high vacuums has a tendency to draw blood or its leucocytes into the udder; that is, to cause "leucocytosis." The comprehensive data secured in these tests indicate that there is no basis for such a belief.

In all the comparisons made, machine-drawn milk appeared to have a lower cell content than hand-drawn milk; and variations in the vacuum used, up to 19½ inches, gave no corresponding changes in cell content. In the vacuum-increase tests, three cows of different ages and milking history, and each in a different part of the lactation period, were selected as experimental animals; and three in similar stages of milk giving and of comparable cell counts were used as checks.

Starting with a vacuum of 14½ inches, five successive increases in the degree of vacuum secured, each of an additional inch of mercury supported, were made at weekly intervals. The high vacuum of 19½ inches was maintained for only one milking and the machines were rapidly returned to the normal by a change at each milking.

The animals showed no physical effect from the vacuum increases; and the changes in cell content of the milk could be connected in no way with the changes in conditions. The milk of one of the experimental animals appeared to increase slightly in cell content as the vacuum increased, with one rather high count after the first rise of an inch and others while the vacuum was at 17½ inches and at 18½ inches, with a return to practically the original figure at 19½ inches and a rise to a high count again when the machine supported only 14½ inches of mercury. The check cow of this pair, without vacuum increases, showed very similar and almost as great changes in the cell content of her milk.

With the second pair of animals, the cell content of the milk of both remained nearly constant throughout the test, the one high count being in the milk of the check cow.

With the third pair, also, the fluctuations in cell count were greater with the cow milked without vacuum changes; and the number for the experimental animal was as low at the high-vacuum milking as at the start or at any time during the test.

These data manifestly show no evidence of " leucocytosis."

Two fresh cows were milked by hand for one week and two and one-half weeks respectively, and then by machine. The average cell content for the last four or five days of hand milking was 510,000 for one cow and 95,000 for the other; and the corresponding averages for the first four days of machine milking were 230,000 and 55,000.

Part of the animals in the Station herd are milked by hand regularly, part by machine, which made it possible to compare quite large numbers of normal samples of milk taken by each method of drawing. Of such samples, 56 from hand milking had an average cell content of 381,000, and 113 from machine milking 309,000.

The facts that half of the Station herd has been milked by machine for years and that the herd as a whole gives a lower average cell count than any other herd examined, appear to confirm the other evidence that machine milking, by the vacuum type of machines, does not increase the cell content of milk or tend to draw cells from the interior of the udder.

Do high cell counts mean unwholesome milk?

The investigations in the Station herd and others have not demonstrated that any relationship exists between the number of cells discharged and specific bacterial infections of the udder. None of the cows in these herds gave " gargety " milk at any time, thus making it impossible to study the influence of that particular udder trouble on cell counts. Some of the cows had aborted, however, and others had previously suffered from diseased udders; but in these cases no consistently high cell counts or abnormal fluctuations were noted that were not duplicated or exceeded in milk of cows apparently normal in every way.

Many udders or quarters of udders showed the presence of large numbers of bacteria of a type undistinguishable by any cultural methods from those producing inflammation of the udder; but the cell counts of the milk when these bacteria were present were sometimes large, sometimes small; so that the evidence so far obtained makes it impossible to decide whether or not the discharge of large numbers of cells in connection with particular types of bacteria has any sanitary significance.

Conclusion.

The studies of the cell content of milk made by the Prescott-Breed method appear to prove the accuracy and utility of the method; they have made it very evident that the presence of large numbers of cells in milk does not

necessarily indicate abnormality; they have shown that the vacuum type of milking machine does not draw blood from the udder or increase the cell content of the milk; and they have made it necessary to secure much additional data before we can say in what way cells in milk can be used as indicators of sanitary quality.

DO DORMANT CURRANT PLANTS CARRY PINE RUST?*

F. H. HALL.

Fungi living on different plant species.

It is a peculiarity of certain rust fungi that they must live part of the time on host plants of entirely different species. The well-known apple rust would disappear in any locality where all cedar trees were cut down so that none were left on which the so-called "cedar apples" could develop. These "apples" are fruiting bodies of this stage of a fungus, and from them the infection spreads, not to other cedar trees, but to the apple. Here the fungus assumes an entirely different form and bears fruiting bodies of a type very unlike cedar apples. These produce spores which may again infect the cedar.

Another fungus of this same type appears in one stage only on the pine and in others on the currant. This fungus, with the two diseases it produces, was unknown in the United States until within recent years and is still uncommon, so there is some hope of restricting its spread. This makes it advisable to prevent its transmission in every possible way. On the currant this fungus produces felt rust, a disease of very little economic importance; but on certain pines — those with needles in groups of five, of which the white pine is most abundant and most important — it causes blister rust, a very destructive trouble.

How the currant and pine fungus spreads.

The fruiting bodies of the fungus in its pine-inhabiting form cannot infect other pines, but very readily pass to species of Ribes (currant and gooseberry), principally the black currant, even though these are at considerable distances from the diseased pine. On the currant leaves, the fungus produces two fruiting forms, one of which *can* infect other currant plants and thus spread the disease rapidly among currants, but *cannot* infect pine; while the other form *can* infect pine but *not* currant.

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* Reprint of Popular Edition of Bulletin No. 374; for Bulletin see p. 231.

As the currant drops its leaves in the fall, it has generally been believed that the plant retains no fungus fruiting bodies in the spring which can infect either currant or pine; but that new outbreaks of the currant rust must again originate in the pine blister-rust fungus.

Mysterious outbreaks.

But outbreaks of currant rust on the Station grounds, first in 1906 and again in 1911 and 1912, cast some doubt on the assumption that the fungus cannot pass the winter on the currant and renew the disease there without the intervention of the pine blister-rust form. Quite careful search had failed to reveal the disease on pine trees anywhere near the Station or near other currant plantations about Geneva, in which the felt-rust had appeared.

This was a rather serious matter; for if the fungus can remain alive on the currant over winter it would be unsafe to ship currant plants from any rust-infected section. The risk to the pine would be too great.

Fungus does not survive winter on currant.

To test the possibility of this overwintering and reinfection of currant in the spring from the felt-rust form of the fungus, about 500 yearling plants of black currant were dug in November, after the leaves had fallen, from a nursery near Geneva in which practically every leaf had shown the disease. These were distributed to various students of plant disease, widely separated over the northeastern United States, and were, after a season of rest, brought into greenhouses and forced into growth. *In no case did the disease reappear.*

This was true, also, in those cases where an attempt was made to spread the infection by means of the fallen leaves. Many of these leaves were saved and kept outdoors in wire baskets until spring, when they were brought into the greenhouses and used to inoculate the currant plants growing therein. No disease resulted, although every condition was made favorable for germination of the fungus spores if any living ones had been present. The same plants, or others under the same conditions, took the disease very readily when inoculated from the fruiting bodies of the fungus found on pine trees.

Diseased pines found.

For, after very careful search by nursery inspectors of the State Department of Agriculture, two such diseased trees were finally found, at quite a distance from the Station, it is true, but in such a position that it was possible to trace to them, through intervening currant plantations, the origin of the very puzzling outbreaks previously observed on the Station grounds and elsewhere. After the greenhouse experiments failed it became morally certain that there *must be* some such trees; and the nursery inspectors determined to examine every five-leaved pine anywhere in the vicinity of Geneva. The two found were in a bunch of eight culls left in the nursery block

after the other trees, probably imported seedlings, had been sold. They were later destroyed, so that it is hoped there will be no further outbreaks of currant felt-rust and no more cases of pine blister-rust near Geneva.

Currant quarantine unnecessary.

Of course, negative experiments cannot *prove* a case; but these careful tests made with so many plants and under such favorable circumstances, seem to show that there is no danger of transmitting either pine blister-rust or currant felt-rust by leafless Ribes plants sent out in the spring. It is therefore believed unnecessary to exclude from shipment currant plants from nurseries where currant rust has prevailed. No pines should, however, be sent out from such nurseries until it is clearly proved that they have not been infected.

SOD MULCH SOMETIMES A SUCCESS.*

F. H. HALL.

Tillage usually best practice in orchards.

A test reported in Bulletin No. 314 of this Station appears to prove quite conclusively that, for apple orchards in New York State, on most soils and in nearly all situations the tillage-and-cover-crop system is superior to the sod-mulch method of handling the soil. In the work now reported, the results of another test show that, under some rather uncommon conditions, the sod-mulch method may give fruit better adapted to certain market demands, and a larger yield, at less expense. But the situations where these conditions are likely to be met are so few that orchards succeeding in them must be considered " exceptions that prove the rule," " Tillage is best."

Hitchings orchard selected for tests.

Probably best known among the representatives of sod-mulch systems in New York State is one among the hills of Onondaga County, southwest of Syracuse. In this orchard was developed the " Hitchings method " of sod mulching, named from the owner of the orchard and originator of the method, Mr. Grant Hitchings, who has united with the sod mulch other original ways of dealing with his trees and fruit, so that his orchards stand for much that is " different " in fruit culture. This farm, as the home of the simplest method of sod mulching, was selected by the Station ten years ago, as a most appropriate place to locate a comparative test of the two strongly contrasted ways of handling orchard soils.

Description of plats.

Three plats were selected for the purposes of the test. A, the largest, is on the comparatively level floor of a valley, at the foot of a rather steep hill on whose slopes lie B and C, the other plats. In A, the trees, two years set when the experiment began, are R. I. Greening and Sutton in alternate rows. Each section — tilled and sod mulch — of this plat, contains nearly two acres.

* Reprint of Popular Edition of Bulletin No. 375; for Bulletin, see p. 503.

In B, each section, with an area of almost an acre, contains one row of each of three varieties, Alexander, Wealthy and Fameuse, the trees being nine years old when the test began. The smallest plat of the three and highest in elevation is C, containing six rows of Northern Spy trees, set one year before the trees in B. The area of each section in this plat is but little more than a quarter of an acre.

The soil in the three plats belongs to the Miami series, ranging from the dark brown, rather tenacious clay loam of the valley floor, moderate in depth, to a deeper soil with more and more stones in the loam, and with some gravelly or sandy spots as the elevation increases in B and C. In all three plats the soil is well supplied with the usual elements of fertility, though somewhat deficient in lime. In B and C the surface of the land is somewhat uneven and the soil, in both depth and character, varies too much to make these plats very suitable for experimental work. "But better plats could not be laid out in the Hitchings orchard and it was much desired that comparison of sod mulch and tillage be made where the mulch system had become most prominent in New York." The general plan of the experiment was outlined at the Station, but the operations were left to Mr. Hitchings' judgment and most of the records were kept by him, as the location is rather inconvenient for frequent visits by Station men.

Culture. The trees were in sod when the experiment began, those in Plat A having been set in sod; and the grass roots have been left undisturbed throughout the ten years on the sod-mulch sections. Once each summer, or twice if necessary, the grass was mowed, and usually left to lie where it fell, to form the mulch. In A, part of the grass was cured for hay the first year and removed, the rest being piled about the trees to cover the area through which the roots spread. In subsequent seasons all the grass was thus placed above the roots of the trees in this plat; and the same plan was followed in B and C for two or three years, after which the grass mulch was left undisturbed, as Mr. Hitchings believed the roots had then met between the rows of trees.

In the tillage section the land was plowed in late April or early May each year, cultivated from seven to twelve times during the summer, with special hoeing or spading about the trees as the owner thought advisable. In one season the trees in one section were hoed five times. In every year but one a cover crop was sowed about August 1. This was usually of mammoth clover or crimson clover but wheat was used twice. This cover crop was turned down the next spring.

Results on fruit. Disappointment followed disappointment on Plat A; for a severe winter at the outset killed several trees and undoubtedly lowered the vitality of many others. Because of this, or, more probably, because the valley

soil and conditions are not well adapted to apple-growing, all of the trees were slow in maturing. When a crop was promised, by a good show of blossoms, untimely frosts or unseasonably cold weather at blooming time destroyed the prospect, so that in the whole ten years only scattering fruits were harvested on this plat. Here, tree-growth alone must be depended on for information as to the effect of the two methods; though this plat, by size, uniformity of soil and conditions, and arrangement of varieties, was considered most promising of all.

On the B and C plats, on older trees, some apples have been produced every year, and in a few seasons the yields have been excellent, for trees of this age. On these two plats, with four varieties, the trees in sod have yielded more fruit in twenty-five instances, those in tilled soil more in thirteen cases, while on two occasions the trees of one variety produced the same amount on each plat. With each variety the average annual yield of trees in sod was greater than that of those under tillage; but the differences were small, ranging from less than a peck with Northern Spy to a bushel and three-quarters with Fameuse.

The fruit on the tilled sections was not as well colored as on sod, and was, for this reason, less desirable for market purposes, especially for a local or semi-private trade such as Mr. Hitchings has developed. The money value of this difference, however, would be hard to fix; and when we consider that high color is most frequently an index of lack of vigor in the trees bearing such fruit we must not place an exaggerated value on this characteristic.

No constant difference in size of fruits grown by the two methods could be distinguished; but in many cases it was quite evident that the increased quantity of apples from the trees in sod was due to greater numbers rather than to larger size.

Effect on trees and foliage.

The fruit yields on two plats apparently show the sod-mulch method better, but tree growth indicates very little difference on these plats and color of foliage shows greater vigor in the tilled trees. On Plat B, Fameuse trees in sod made an average gain in tree diameter, during the ten years, of .89 inch more than those under tillage, while Wealthy trees reversed this showing with an increased gain of .73 inch for the tilled trees. On Plat C, Northern Spy trees made almost identically the same gain under the two methods.

In no case, with these varieties on B and C, was the foliage better on the trees in sod and was as good only early in the season or after heavy rains. At all other times the tilled trees showed a darker green in their foliage; and in four seasons when observations were made they held the foliage longer in the fall. On A, with the younger trees, these foliage differences were much more noticeable and at

times striking, thus showing clearly the greater vigor of the trees on tilled soil. On this plat, tree diameters confirmed the evidence of the foliage; for both Greening and Sutton trees on the tilled section were more than an inch greater in diameter than those on sod, the Suttons nearly an inch and a quarter greater. These are considerable differences for trees of this age, and can not be considered as accidental, since 150 trees were measured.

These figures plainly show greater vigor for tilled trees on this plat while on the other plats no such difference appeared. How is this to be explained? First, the soil on the hillside is deeper than that in the valley and gives the trees a larger feeding area so that the roots can get away from the grass; and, second, on the hillside there is an almost constant seepage of water from higher up the slope, which affords an abundance of moisture for both trees and grass. In the comparatively shallow and dry soil of the valley the trees in sod can not compete successfully with the grass for either water or food, and therefore suffer.

Expense. With crop yields favoring the sod mulch under these conditions, the exact cost of production is not needed to prove it the better method in this orchard, for it is quite evidently cheaper to leave land in sod than to till it. It is well that the case is so plain, for it would be hard to reach a fair average for the cost of cultivation from the data secured in these tests. The plats were so small that the expense of handling them as units was greatly increased; and it is doubtful whether many orchards would require, or at least receive, as many cultivations during the season as were given the tilled sections of these plats. In brief, however, the cost of cultivation in A, the large plat in the valley, was $11.22 per acre annually; in B, the second plat in size, at the base of the hillside, $13.30, and in C, the small plat well up the slope on steeper grades, was $24.33 per acre. The cost of mowing the grass averaged 72 cents an acre.

Other considerations. The relative cost of the two methods, even were crops equal, makes sod mulch better for Mr. Hitchings; and he finds other advantages. Under his method of harvesting, which is to allow many of the varieties to ripen on the tree and drop, or to shake them off, the exposed dirt under the tilled trees is decidedly objectionable, as it bruises and soils the fruit. This, with the poorer color of the red varieties under tillage, makes apples thus handled less acceptable in market.

Where is sod mulch applicable? From the behavior of the Hitchings orchards, New York apple-growers may infer that there are particular places, soils and economic conditions under which the Hitchings method of sod-mulching apple trees may be used advantageously. Since the prerequisites for the success of the method, as indicated by the Auchter and Hitchings orchards, are not very generally found in this State, the

situations in which sod may be given preference over tillage should be set forth with exactitude.

1st. *Orchards on steep hillsides where land would wash badly under tillage may be kept in sod.*—There are few commercial apple orchards in New York in which cultivation may not be so managed that soil erosion will not interfere seriously with the tillage-and-cover-crop system. It is probable that clover or some other legume might be substituted advantageously for the blue grass and orchard grass of the Hitchings method where sod is desired to keep water from wearing the land away.

2d. *Land covered with rocks, whether steep or not, must often be kept in sod because of the impossibility of tilling.*— There are not a few such orchards in New York.

3d. *The Hitchings method is best suited to soils having considerable depth.*— It is adapted only to soils in which grass roots and tree root do not come in too intimate contact and too direct competition for food and moisture. The commercial apple orchards of New York are at present on lands the top soil of which averages less than a foot in depth. On these shallow soils the Hitchings method will prove a failure.

4th. *Soils must be retentive of moisture.*— To sustain trees at their best under the Hitchings method, soils must not only be deep but must be very retentive of moisture, or have the water table comparatively close to the root run of the trees, or, as in the case of the orchards under discussion, must be fed by seepage from higher ground nearby. On land that suffers from summer drouths, this sod-mulch treatment will almost certainly prove less beneficial to trees than tillage.

5th. *Economic conditions may decide the choice between tillage and some mulching treatment.*— The cost of caring for a sodded orchard is materially less, under this mode of mulching at least, than by tillage. If, then, a man chooses to grow apples extensively, rather than intensively, he may make larger acreage in sod counterbalance greater production under tillage thereby bringing the cost of production to the same level.

The lesson of the Hitchings orchard.

The chief lesson taught by the Hitchings orchard, with its unique features, is that a man may break away from the common practice, when circumstances render such practices difficult or impossible, and yet attain a high degree of success. The method of orcharding which takes its name from the Hitchings orchard is not as valuable to the fruit-growers of New York as is the demonstration by Mr. Hitchings that new paths to success may be blazed — new practices devised to meet new conditions, old obstacles overcome in new ways. It is a splendid and successful example of resourceful pioneering and of persistent endeavor to attain the highest success. The pith and the point of the work in this orchard, so different from

other orchards in the State, is that fruit-growing is intensely individual. The prime factor is the man.

But from the success of Mr. Hitchings the apple-grower must not be led away from the general truth, that the individual problem can be solved most often by the rational application of the laws of nutrition and growth which plants generally follow. Applied to the problem of growing apples in New York, the general law is, that the apple, like other orchard, field and garden plants, responds to cultivation.

PURITY OF FARM SEEDS IN 1913.*

F. H. HALL.

Adulteration of seeds decreasing. The seed inspection law of New York State is securing some of the good results expected from it. Only $17\frac{1}{2}$ per ct. of the samples collected in 1913 failed to reach the standard set by the law, while in 1912 almost 21 per ct. were in violation of its provisions.

The mixed grass seeds, such as the lawn mixtures, were poorest in quality, as three of the six samples, or 50 per ct., were in violation of the law. One of these samples contained only 37 per ct. of pure seed and another less than 50 per ct. Those who wish to use mixtures of different grasses will find it much safer and more economical to buy the seeds of the several kinds desired and mix them at home. Almost as large a percentage of alsike clover samples as of lawn grass were in violation of the law, 44 per ct. of the 34 samples; but the quality of the seed was very much better, since only one sample showed less than 75 per ct. of pure seed, one other less than 80 per ct. and eight others less than 90 per ct. Red clover was somewhat better than alsike, with 25 violations out of 85 samples, or about 30 per ct., of which only one sample contained less than 85 per ct. of pure seed, and three others less than 90 per ct. Redtop was not as good as it should be, showing 17 per ct. of violations, with one sample containing less than 65 per ct. of pure seed, one 75 per ct., and nine others less than 90 per ct. White clover was still better, with one violation only out of eight samples, and this contained more than 90 per ct. of good seed. The one violation among the nine samples of blue grass contained almost 90 per ct. of good seed, but one other sample, not a violation of the law since it contained only small quantities of other seeds, was so mixed with rubbish that it showed less than 75 per ct. of good seed, two samples only 80 per ct., and none of the remaining five samples was over 91 per ct. The examination of timothy seed brought to light only one violation in 86 samples, with 95 per ct. of pure seed; and practically all the other samples showed 97, 98, even 99 per ct., or better, of good timothy.

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* Reprint of Popular Edition of Bulletin No. 378; for Bulletin see p. 690.

No samples contrary to law were found in alfalfa, crimson clover, millet, orchard grass, rape or vetch; but the orchard grass contained too large an amount of rubbish to entitle it to very high grade.

Seed law only partial protection.

From some of the cases mentioned above it will be seen that the seed law does not safeguard the purchaser to anything like the same extent as other inspection laws. The fertilizer law requires the manufacturer or dealer to guarantee the amount of valuable ingredients in the brand; and the feeding stuffs law demands, in addition, that one rather undesirable ingredient, fiber, shall not exceed a certain minimum without an explicit statement, among the other guarantees, of its presence and amount, and also that all constituents of mixed feeds shall be named on the container.

The seed law, on the contrary, requires no guarantee of the amount of pure seed, but merely that a label must be used if the seeds contain "in excess of three per centum . . . of foul or foreign seeds." This makes it very necessary for the purchaser to examine closely the seed he is about to buy, even if he has the dealer's guarantee that it complies with the law. Personal examination will usually detect any considerable amount of rubbish present, like sand, gravel, chaff, pieces of plant stems, joints of grasses or similar material, for such substances are much more easily recognized than foreign seeds. If the seed appears to contain considerable amounts of such rubbish, the buyer should insist that it be cleaned before he takes it, secure a reduction in price proportionate to the amount of impurity, or look elsewhere for his supply.

The seed buyer should also make sure that the seeds of pernicious weeds are not included among the impurities in the seed he secures.

Alfalfa seed under the limit of "three per centum of foul or foreign seeds" and hence legally sold without a label, might contain enough wild mustard seeds to give 120,000 plants of this pest to the acre, enough of Canada thistle to give 300,000 plants, or of alfalfa dodder to give 350,000 plants.

Again, the samples of seeds do not represent goods that are likely to be as uniform in source and quality from year to year as are the standard brands of fertilizers and feeds.

For these reasons, the seed inspection bulletin under the present law can not be as useful a guide in the purchase of seeds as are the other inspection bulletins in respect to the goods they cover. However, the knowledge that the seeds they handle are liable to sampling and analysis, with public announcement of the results and prosecution for violations, makes dealers much more careful in regard to seed quality, so that, as we have seen, there has been a general, and not inconsiderable, improvement in seed-trade conditions in 1913 as compared with 1912.

The regular bulletin bearing the same number as this "popular edition" contains the results of these official inspection analyses. This bulletin will be sent on request, but its somewhat limited usefulness seems to make it inadvisable to send it to all on the Station mailing list, as is done with the fertilizer and feeding stuffs bulletins.

Voluntary examinations. The seed-inspection law is so restricted in scope that even with the yearly bulletin at hand, the individual purchaser would have little assurance as to the quality of the seeds in his market; therefore the Station will continue, until the demands overtax its facilities, to make examinations of samples for farmers who wish to sow only pure seed. Certain conditions are essential, however, if the samples are to furnish reliable information.

First, the sample must be large enough to represent fairly the quantity of seed from which it is taken. This means at least two ounces for the larger seeds, like alfalfa, the clovers, millet and rape, and at least one ounce for grass seeds.

Second, the sample should be taken from lots from which the dealer agrees to supply the purchaser's needs after the report of the analysis has been received. The small packets or samples sometimes furnished by dealers are frequently taken from seed specially cleaned for advertising purposes; and examination of them serves to delude rather than to enlighten the sender.

Third, in taking samples, the bulk of seed should be thoroughly mixed, or small quantities should be taken from top, middle and bottom of the bag or other container and mixed before taking out the amount to be sent to the Station.

Fourth, the sample should be sealed in a strong, tight package that will not be easily broken in the mail, and marked plainly with the name and address of the sender. It is not sufficient to send an unmarked package with a separate letter describing its contents, as the Station may receive a score of seed samples in a single mail.

If these conditions are complied with, the Station will examine the samples as promptly as possible, usually within two days, and report to the sender at once, giving the percentage of pure seed, percentage of rubbish and percentage of other seeds, with an indication of the kind and quantity of specially undesirable weed seeds present. A statement is also usually made as to the general quality of the seed; but the Station does not make germination tests. It must be thoroughly understood that these examinations will be made for farmers only, or for other intending purchasers of seed for farm use. The Station can not and will not examine seeds for dealers or others who wish to know their quality for purposes of sale, or for labeling under the law.

THOROUGHNESS PAYS IN POTATO SPRAYING.*

F. H. HALL.

Potato spraying neglected. New York State potato-growers still have much to learn about spraying. Many of them apparently know little about the benefits from this practice, since they fail to spray at all. Others evidently believe in spraying, but make too few applications or put them on too carelessly to obtain the most profitable results. In one of the most important potato-growing sections of the State, near Rush, the Station sprayed small areas in 66 fields, in only 19 of which, or less than 29 per ct., did the owners spray at all. It is probable that not much over one-fourth of the potato-growers of the State spray. This is somewhat surprising, for the Station has urged the practice for many years, and in two series of tests, one extending over nine years and the other ten, has proved clearly that spraying is a most profitable insurance investment. In the ten-year tests under Station conditions the average increase was at the rate of 97½ bushels per acre annually; while in the farmers' business experiments extending over nine years, spraying gave a net profit in 94 cases out of 114, or 82.4 per ct., and the average annual net gain, financially, was $14.43 per acre on over 1,500 acres. Thus there is a certainty of a nice gain from spraying, if made a regular practice, with only slight possibility of loss in a few cases, as the average loss in the 20 cases where any occurred was only $5.78 an acre on 233½ acres.

Station work enforces thoroughness. The average gain in yield in the Station tests, almost 100 bushels to the acre, is much better than the average in the farmers' business tests, 36 bushels; which seems to indicate a difference in thoroughness between Station spraying and applications made on the farm. It is probably true, however, that yields at the Station, on strong soil and with good culture, are better than yields generally and the gains from spraying therefore greater. Hence, to test the

* Reprint of Popular Edition of Bulletin No. 379; for Bulletin see p. 244.

effect of thoroughness it is necessary to do the work on farms where all conditions, except the spraying, are such as the average farmer would meet.

Work at Rush. Accordingly arrangements were made by which the Station secured the right to spray one-fiftieth of an acre in each of many potato fields near Rush. The Station employed a man (a Cornell student, during his summer vacation) to measure the required area in each field and to spray the vines thoroughly every two weeks. As already stated, no bordeaux spraying was done by the owner in 47 of the 66 fields selected; while in the other 19 fields the Station spraying was in addition to from one to eight treatments by the owner. The Station work was done with a knapsack sprayer, thoroughly and repeatedly, so that five applications were made on late-planted fields and six on those planted earlier.

Results. The season was a very poor one for testing any spray treatment, as dry weather restricted growth and prevented development of fungus diseases, while a frost on the night of Sept. 14, when the sprayed vines were still green and vigorous, cut the season short two or three weeks. Very little early blight appeared and no late blight, so that the greatest factors in spray benefit were absent; yet by a somewhat better control of "bugs" in a few instances, some repression of tip-burn and by the little-understood stimulus of the copper sulphate on potato plants, spraying resulted in increased yields in 41 out of 47 unsprayed fields and in 15 out of 19 of those sprayed more or less frequently and thoroughly by their owners. The average net gain, as measured by the difference between the actual weighed yield of the sprayed row and of an equal length of check row beside it, was at the rate of $17\frac{3}{4}$ bushels per acre where no spraying was done by the owner and 15 bushels where the owner sprayed and the gain came from the added applications or more thorough work in the Station spraying.

Lesson of the test. These tests confirm the belief gained from previous potato spraying experiments, that this operation is seldom performed at a loss and is generally very profitable. Certainly conditions would rarely be as unfavorable for showing benefit from spraying as in these cases, yet in probably more than one-third of the fields there was a financial profit from the spraying, no gain or very slight loss in another third of the fields, and a small loss on most of the remaining fields. This applies with almost equal force to sprayed and unsprayed fields.

The work also enforces the necessity for careful, thorough and repeated applications if the greatest benefit is to be secured; for there was apparently, in this dry season, little gain from much of the spraying done by the growers themselves.

SOME FERTILIZER TESTS IN VINEYARDS.*

F. H. HALL.

Declining grape yields demanded investigation.

In the Chautauqua Grape Belt the vineyard area increased fully one-third between 1900 and 1913, but the yield of grapes for the last half of this period was only $3\frac{1}{2}$ per ct. greater than for the first half. In other words, while the area increased, the yields per acre decreased, so that many vineyards became a source of loss rather than gain to their owners. The very poor crop cf 1908 called attention forcefully to the need for investigation into the cause, or causes, of the reduced yields, and an appropriation was secured from the State Legislature to support such work. In the spring of 1909 this Station leased a 30-acre farm near Fredonia on which there was already a large vineyard, and sent a corps of investigators into the field to learn, if possible, why these declines in yield had occurred.

A general survey of the situation made it clear than many vineyards had been planted on soils too thin, too infertile or too poorly drained to be suitable for grape culture; but many vineyards were noted, both old and young, on good soils but not producing profitable annual crops. Here something was evidently amiss, and it has been the object of the Station studies and tests to locate the unfavorable influences. Already much has been done to enable grape-growers to control certain insect pests that have, at times and over quite wide areas, seriously reduced crops; and directions for handling these foes have been given in Bulletins 331, 344, and 359 of the Station. In this bulletin there is presented a summary of five years' work in applying commercial fertilizers in order to insure an ample supply of plant food for the vines and the fruit they should bear.

A preliminary survey of conditions relative to the use of fertilizers in this district showed no uniformity of practice and no consistent gains from the many fertilizing materials and combinations used in different vineyards. The only conclusion that could be reached from this survey was " that growers who had used commercial fertilizers regularly, other conditions being the same, had secured less variable crops from year to year, than those who had made irregular and scant applications or none at all."

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* Reprint of Popular Edition of Bulletin No. 381; for Bulletin see p. 572.

Range and results of tests.

Five years' work with commercial fertilizers has now been completed in the leased vineyard at Fredonia; and from two to four years' work with similar fertilizers, and in some cases with manure and cover crops also, has been carried on in cooperation with the owners of six other vineyards in different parts of the Grape Belt.

The results prove, mainly, that the problem of grape fertilizers is very dependent on other factors, and no very definite conclusions as regards specific applications have been reached through these comprehensive tests.

In the Fredonia vineyard, readily available nitrogen appears to be a determining factor in crop yields; but the other tests give no positive indications in the same direction. In these tests the duplicate plats in many instances give variant results; or the favorable influence of a fertilizer element in one combination will be offset by a loss or no gain when the same element is used in another combination. The conclusions which might be drawn from one vineyard are also quite liable to be at variance from those furnished by another vineyard under apparently comparable conditions.

Tests at Fredonia.

In the vineyard at Fredonia eleven plats were laid out in a section of the vineyard where inequalities of soil and other conditions were slight or were neutralized. Each plat included three rows (about one-sixth of an acre) and was separated from the adjoining plats by a "buffer" row not under test. One plat in the center of the section served as a check, and five different fertilizer combinations were used on duplicate plats at either side of the check. Plats 1 and 7 received lime and a complete fertilizer with quick-acting and slow-acting nitrogen; Plats 2 and 8 received the complete fertilizer but no lime; on Plats 3 and 9 potash was omitted from the complete fertilizer combination; Plats 4 and 10 received no phosphorus; Plats 5 and 11, no nitrogen; and Plat 6 was the check. The materials were applied at such rates that they provided for the first year 72 pounds of nitrogen per acre, 25 pounds of phosphorus and 59 pounds of potassium; and for each of the last four years two-thirds as much nitrogen and phosphorus and eight-ninths as much potassium. The lime was applied the first and fourth years in quantity to make a ton to the acre annually. Cover crops were sown on all plats alike and were plowed under in late April or early May of each year. These differed in successive years, but included no legumes. The crops used were rye, wheat, barley and cowhorn turnips separately and the last two in combination.

The cultivation differed only in thoroughness from that generally used in the Belt, the aim being to maintain a good dust mulch during the whole growing season. Pruning by the Chautauqua System was done throughout by one man, who pruned solely according to the vigor of the individual vines and left four, two or three, or no fruiting canes as appeared best. The vineyard was thoroughly sprayed, all plats alike.

Low winter temperatures, affecting immature wood and buds caused by unfavorable weather of the previous season, reduced yields materially during two of the five years, and practically neutralized any anticipated benefit from fertilizers. Following the first of these low-crop years, came a season, 1911, in which favorable conditions, acting upon vines left undiminished in vigor by the light crop of the previous year, resulted in heavy and quite uniform yields on all the plats.

The yields for the five years are shown in Table I; and a summary showing the average gains from each treatment is given in Table II, with the average financial balance after deducting the cost of fertilizer application from the increased returns from the plats receiving them.

TABLE I.— YIELD OF GRAPES (TONS PER ACRE) IN FERTILIZER EXPERIMENTS.

Plat No.		1909.	1910.	1911.	1912.	1913.	5-year average.
		Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1	Complete fertilizer; lime	4.48	2.10	5.37	3.46	2.14	3.51
2	Complete fertilizer	4.76	2.21	5.71	4.30	2.83	3.96
3	Nitrogen and phosphorus	5.17	2.14	5.61	4.00	2.25	3.83
4	Nitrogen and potash	4.25	2.55	5.64	4.10	2.85	3.87
5	Phosphorus and potash	3.41	2.00	5.44	4.35	1.78	3.39
6	Check	3.38	2.10	5.32	3.60	1.24	3.12
7	Complete fertilizer; lime	4.69	2.38	5.62	4.80	3.04	4.10
8	Complete fertilizer	4.66	2.07	5.71	4.98	2.72	4.02
9	Nitrogen and phosphorus	4.99	2.04	5.35	4.89	2.61	3.97
10	Nitrogen and potash	4.79	2.26	5.91	4.89	3.07	4.18
11	Phosphorus and potash	4.99	1.87	5.03	4.21	1.97	3.61

TABLE II.— AVERAGE INCREASE IN GRAPE YIELDS AND AVERAGE FINANCIAL GAIN FROM FERTILIZER APPLICATIONS.

N = nitrogen, P = phosphorus, K = potash, Ca = lime. Gains in tons per acre.

	N, P, K, Ca.	N, P, K.	N, P.	N, K.	P, K.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
First plat of pair	3.51	3.96	3.83	3.87	3.39
Second plat of pair	4.10	4.02	3.97	4.18	3.61
Average	3.80	3.97	3.90	4.02	3.50
Check plat	3.12	3.12	3.12	3.12	3.12
Average gain	.68	.85	.78	.90	.38
Average financial gain	$5.82	$13.84	$14.05	$18.54	$6.99

From this last table the benefit from nitrogen appears quite evident since every combination in which it appears gives a substantial gain over the one from which it is absent. Phosphorus and potassium, without the nitrogen, lead to only a slight increase over the check;

and lime appears to be of no benefit. Financially, the complete fertilizer and lime combination, the nitrogen and phosphorus combination and the phosphorus and potassium combination failed to pay their cost in five of the ten comparisons; the complete fertilizer was used at a loss four times out of ten; and the nitrogen and potassium combination three times out of ten. Lime had no appreciable effect on either vines or fruit.

No effect of the fertilizers on the fruit itself, aside from yield, was shown for the first three years; but in 1912, and even more markedly in 1913, the fruit from the plats on which nitrogen had been used was superior in compactness of cluster, size of cluster and size of berry. In 1912 also, when early ripening was a decided advantage, the fruit on the nitrogen plats matured earlier than that on the check plats. In 1913 the favorable ripening season and the smaller crop tended to equalize the time of ripening on all plats. The grapes on the phosphorus-potassium plats were better in quality than those in the check plats but not as good as those on the plats where nitrogen was used.

Other indexes also show plainly the benefit from nitrogen in this vineyard; for size and weight of leaf, weight of wood produced and number of fruiting canes left on the vines were all greater where fertilizers, and particularly nitrogen, had been used. The three-year averages (1911–1913) of the measurements for these characteristics are shown in Table III.

TABLE III.— COMPARATIVE PRODUCTION OF LEAVES, WOOD AND FRUITING CANES ON GRAPE VINES DIFFERENTLY FERTILIZED.

(Averages for three years.)

FERTILIZER APPLICATION.	Leaf weight.*	Wood pruned.†	Fruiting canes left.‡
	Grams.	*Lbs.*	
Complete fertilizer; lime	1,033	1,295	2,468
Complete fertilizer	1,010	1,367	2,609
Nitrogen and phosphorus	1,047	1,272	2,585
Nitrogen and potassium	1,069	1,401	2,646
Phosphorus and potassium	964	1,086	2,326
Check	930	915	2,110

*Each weight is of 300 green leaves, 5 from each of 60 vines. The first leaf beyond the last cluster was selected.

† Amount per acre of wood pruned in fall.

‡ Number per acre.

Cooperative experiments. In order to secure information as to the behavior of fertilizers on the different soils of the Grape Belt, cooperative tests were carried on in six vineyards owned, respectively, by S. S. Grandin, Westfield; Hon. C. M. Hamilton, State Line; James Lee, Brocton; H. S. Miner,

Dunkirk; Miss Frances Jennings, Silver Creek; and J. T. Barnes, Prospect Station. The soil in these vineyards included gravelly loam, shale loam and clay loam, all in the Dunkirk series, and the experiments covered from two to two and a half acres in three cases and about five acres in each of the other vineyards. The work continued four years in all but one of the experiments, which it was necessary to end after the second year.

The general plan of the tests was much like that at Fredonia in most of the vineyards, with the additions of plats for stable manure and for leguminous and non-leguminous cover crops with and without lime. From two to six check plats were left for comparison in each vineyard. As already stated the results were often inconsistent in duplicate plats in the same vineyard, and if one test appeared to point definitely in a certain direction, the indication would be negatived by results in other vineyards. In these experiments the yield of fruit was the only index to the effect of treatments; as it was not possible to weigh leaves or pruned wood, or to count the canes left.

Commercial fertilizers in cooperative tests.

Nitrogen and potassium in combination, which gave the largest gains and greatest profit in the Station vineyard at Fredonia, showed a 13 per ct. increase in yield on one plat in the Jennings vineyard and a 9 per ct. decrease on the other; in the Miner vineyard this combination apparently resulted in a 25 per ct. increase, in the Lee vineyard in a 2½ per ct. loss; in the Hamilton vineyard a 17 per ct. gain; and in the Grandin vineyard neither gain nor loss. In only two of the five vineyards in which this combination was tested was the gain great enough to pay the cost of the fertilizer applied. Similar discrepancies, or absence of profitable gain, mark the use of the other fertilizer combinations.

Manure and cover crops in cooperative tests.

Even stable manure, the standby of the farmer and fruit-grower, when applied at the rate of five tons per acre each spring, and plowed in, did not, on the average, pay for itself. Indeed, there were few instances among the 60 comparisons possible, in which more than a very moderate profit could be credited to manure. The average increase in yield following the application of manure alone was less than a quarter of a ton of grapes to the acre; while the use of lime with the manure increased the gain to one-third of a ton per acre. The ton of lime to the acre annually would not be paid for by the gain of 175 pounds of grapes. Cover crops were used in five of the six cooperative experiments; and proved even less adapted to increasing crop yields than did the manure. There was no appreciable gain, on the average, from the use of mammoth clover; indeed, a slight loss must be recorded for the clover except upon the plats which were also limed, and even with the lime the average yields on check plats and

mammoth clover plats differed by only one one-hundredth of a ton. Wheat or barley with cowhorn turnips made a slightly better showing, as the plats on which these crops were turned under, without lime, averaged about one-twentieth of a ton to the acre better than the checks. With these non-legumes, lime was apparently a detriment, as the plats with the lime yielded a tenth of a ton less, on the average, than those without it.

Suggestions from the results.

The results of the several tests of which this bulletin is an account throw comparatively little light on the value of fertilizers for grapes. It is evident that the fertilization of vineyards, as well as of orchards, fields and gardens, is so involved with other factors that only carefully planned and long continued work will give reliable results. Indeed, field experiments even in carefully selected vineyards, as the cooperative experiments show, may be so contradictory and misleading as to be worse than useless if deductions are made from the results of a few seasons. The work that has been done is not without value, however, for it has brought forth information about fertilizing vineyards that ought to be most helpful to grape-growers. Thus the results suggest:

First, and most important, that it is usually waste, pure and simple, to make applications of fertilizers in poorly-drained vineyards, in such as suffer frequently from winter cold or spring frosts, where insect pests are epidemic and uncontrolled, or where good care is lacking. The experiments furnish several examples of inertness, ineffectiveness, or failure to produce profit where the fertilizers were applied under any of the conditions named.

Second, it is certain in some of the experiments and strongly indicated in others that the soil is having a one-sided wear — that only one or a very few of the elements of fertility are lacking. The element most frequently lacking is nitrogen. The grape-grower should try to discover which of the fertilizing elements his soil lacks and not waste by using elements not needed.

Third, the marked unevenness of the soil in all of the seven vineyards in which these experiments were carried on, as indicated by the crops and the effects of the fertilizers, furnishes food for thought to grape-growers. Maximum profits cannot be approached in vineyards in which the soil is as uneven as in these, which were in every case selected because there was an appearance of uniformity. A problem before the grape-growers of Chautauqua county is to make more uniform all conditions in their vineyards.

Fourth, a grape-grower may assume that his vines do not need fertilizers if they are vigorous and making a fair annual growth. When the vineyard is found to be failing in vigor, the first step to be taken is to make sure that the drainage is good; the second step, to control insect and fungus pests; the third, to give tillage and good care; and the fourth step is to apply fertilizers if they be found necessary.]

CONTROL OF CABBAGE MAGGOT ON EARLY CABBAGE.*

F. H. HALL.

Cabbage maggot injuries serious.

Any pest which attacks the roots of plants must be considered a dangerous enemy. The injury involves the parts most essential to the life of plants; and the pest itself is liable to be so hidden from view that its presence will become known only when the effects of its work appear, which is frequently too late for effective control. The concealment in the soil, also, and the protective influence of this cover make repressive measures very difficult and uncertain. For these reasons, control of the cabbage maggot has long been a problem for entomologists. In the growing of late cabbage, however, the insect is not to be feared in the field, since its ravages for the season are over before the plants are set; and the practice of screening seed beds (discussed in Bulletins 301 and 334 of this Station) makes it possible to secure, at only slight expense, healthy, uninjured, vigorous plants to set.

Work on early cabbage.

Upon early cabbage, on the contrary, the cabbage maggot is a field pest; and its injuries are sometimes so severe as to destroy all hope of profit from the crop. In order to secure the best prices for early cabbage, the heads should be ready for market in July; and this means that the plants must be set in the field — from greenhouses or cold frames — in late April or early May. Shortly after this time (May 20 to June 5) the cabbage maggot flies

* Reprint of Popular Edition of Bulletin No. 382; for Bulletin see p. 405.

appear and are busy laying their eggs. From these the larvæ hatch in a few days so that when the young plants should be making their best growth the maggots are most abundant and most busily at work. In consequence, entire plantings of early cabbage sometimes present the appearance of the check rows shown on the title page and in Plate XX; and the roots, upon examination, are found to be as pictured in Plate XXIV.

Use of insecticides.

Against this pest, only two methods of control are practicable — the young maggots may be killed by injecting into the soil some contact insecticide, or the flies may be prevented from laying their eggs about the plants. Many materials have been tested for the purpose of destroying these larvæ, but, in the main, without thoroughly satisfactory results. If strong enough to kill the maggots the materials employed have also been strong enough to injure the delicate roots of the plants and to so stunt them that the crops have been little better than they would if the insects had been allowed to work undisturbed.

The experiments made by other entomologists, some of them dating back thirty years, and preliminary tests made at the Station seemed to indicate that carbolic acid emulsion was most promising of all the insecticides suggested, and it was decided to make a series of thorough tests with it in both laboratory and field.

Tests of caroblic acid emulsion.

In the laboratory, direct immersion of eggs of the maggot flies in the emulsion, even when as strong as 1⅓ per ct. of carbolic acid, did not affect them; but when the eggs were covered with soil and treated with emulsion, so that the exposure was more prolonged, as it would be in the field, few of the eggs hatched and the larvæ that did hatch died near the eggs. This was true even when the emulsion contained only one-third of one per ct. of the acid.

Field tests with the emulsion were made during two different years on cabbage seed beds near Seneca Castle, but it proved wholly ineffective, though not injurious to plants five to seven

inches high. On plants one or two inches high the same emulsion was very injurious. In tests on transplanted cabbage, in two fields — one heavy clay and the other light sand — an emulsion slightly stronger than one-third of one per ct. acid caused serious injury to recently set plants. Plants longer set were not injured. As a result of all these tests with insecticides, then, even the one commonly regarded as best is a very uncertain dependence against cabbage maggot. Although it will destroy eggs and young maggots when used at a strength of one-third of one per ct. carbolic acid, it will not kill older larvæ; and it is certain to injure small or recently set plants and liable to do some harm even to older plants.

Tar-pads.

There remains, therefore, only one resource— to prevent the flies from laying their eggs on the plants. The so-called "repellent" materials—lime, ashes, tobacco dust, tar, etc.— have proved either wholly ineffective or too expensive to use; but one mechanical obstruction to egg-laying — the "tar-pad" or hexagonal tar-paper collar — has given excellent results and can be applied at only slight expense.

These pads are made from single-ply tarred felt, are hexagonal disks about 3 inches from angle to angle, slit to the center at one angle and with a short cross cut at the center which allows the collar to fit about the stem of the plant. When placed in position it should lie close upon the ground and fit snugly about the stem, so that the flies of the cabbage maggot are mechanically prevented from reaching the stem at the point where the eggs should be laid, just at, or slightly below, the surface of the ground. These pads can be easily and rapidly cut by the use of a special tool, not patented, and easily made by any good blacksmith. The pads can be made for from 50 to 55 cents a thousand.

The idea of using such pads was first proposed about 25 years ago, and they have been used with good success in several localities since that time. In New York State, however, their adoption has not been general, though they are made commercially by firms on Long Island and at Rochester.

Tests of tar-pads.

At the Station four careful tests with these pads were made during 1912 and two during 1913, and the results justify a hearty recommendation of this method of preventing injury to early cabbage by maggots. In three of the tests injury from maggots was great and benefit from use of the pads was marked. In the first field 400 disks were applied to four alternate rows of plants on May 22, and during the next month ten per ct. of the check plants were either killed or badly wilted, as compared with one per ct. of those protected by the tar-pads. In addition to this notable numerical difference, the cabbages in the protected rows were slightly larger than those in the check rows. That is, maggots had worked on the unprotected plants and checked their growth even where the attack was not severe enough to result in death or distinct dwarfing. This same effect was observed in all the other tests where maggots were abundant. This check to growth materially interferes with early heading, a most important factor in profitable marketing of early cabbage. In the second test 16 per ct. of the check plants were killed or seriously injured, as compared with 5½ per ct. of those protected. In this case the lumpy condition of the clay soil and low setting of the plants made it impossible to place the disks so that effective protection could be secured in all cases, and a heavy shower soon after placing the disks covered many of them with earth and allowed the flies to deposit eggs on the stems above the pads.

In the third test of 1912, the injuries on checks and protected rows were eight per ct. and two-thirds of one per ct. respectively. In the most striking test in 1913 disks were placed on about 700 plants in six alternate rows, on May 3. By June 5 the alternate rows showed marked differences, as brought out in the illustrations. It was estimated on June 9 that 93 per ct. of the protected plants and only 45 per ct. of the checks would make marketable heads.

After harvest it was found that nearly three-fourths of the plants in the protected rows had furnished suitable heads for early marketing and only one-fifth of those on the check rows.

On the basis of 1,000 plants, the results were as follows:

1,000 protected plants	yield	723	marketable	heads
1,000 check "	"	193	"	"
Gain due to tar-pads...		530	"	"

Value of 530 heads at $8\frac{1}{3}$ cents per head....	$44 17
Cost of protection	1 40
Net profit per 1,000 protected plants....	$42 77

Maggot injury unevenly distributed. In two of the tests of the first year and in one the second year, cabbage-maggot injury was comparatively slight, even on the check rows, although other fields nearby suffered severely from the pest. This restricted distribution of maggot infestation is a factor that must be considered by each grower; for fields adjacent to those badly infested, or even certain areas in infested fields, may be comparatively free from the insects and therefore need no protection. In testing the utility of the use of the pads it will be well to apply them on alternate rows, leaving the intervening rows as checks, in order that the extent of the infestation and the effectiveness of the pads may be more readily learned. If uninfested areas of considerable size are noted, they should be kept under observation in subsequent years, as soil or other conditions there may regularly make these areas practically immune to maggot injury, so that pads need not be applied.

Conclusions. These tests prove quite plainly and conclusively that where maggots are abundant and where conditions are such that the pads can be properly applied, these tarred-paper disks serve as efficient protectors of the cabbage plants. They not only prevent serious injury to practically all the plants, but protect all from the slighter infestation which re-

tards growth and makes the earliest and most profitable marketing of the crop impossible. Their use has advantages over the use of carbolic-acid emulsion, aside from the greater certainty of protection and liability of the latter to injure the plants. It is easier to apply the pads than to make one application of the emulsion, and to insure effectiveness of the carbolic acid, repeated treatments are necessary. In using the emulsion, also, the grower is apt to delay treatment too long; while the pads are best applied as soon as the plants are set and then need no further attention.

Cost. In the past, the tarred-paper disks have been offered for sale at about seventy cents a thousand, and they can be made at home for less than this. In our experiments on sandy soil, with plants of suitable size, one man was able, without any previous experience, to adjust the pads carefully at the rate of 300 per hour. On this basis the cost of protecting cabbage will run approximately from $1.35 to $1.50 a thousand plants. The labor cost will vary according to the character and condition of the ground, and the way in which the plants are set. It is difficult to protect properly, by the disks, plants that are set low in the ground or are wilted.

Recommendations. In the employment of tar-pads as a means of protecting early cabbage, truckers should arrange to transplant seedlings of good size with rather long stems. Disks cannot be satisfactorily adjusted about small plants, for in setting such seedlings it is necessary to place them low in the soil so that only the leaves protrude. Moreover, while transplanting it is well to avoid placing the seedling in a depression. This frequently occurs when the work of setting is done by hand, for in making a hole for the roots more earth is removed than is necessary, so that after the operation is completed the plant occupies the center of a shallow basin. Tar-pads placed about cabbages that have been set in such situations are liable to become covered with soil during the first shower, which reduces their efficiency.

Some growers set their cabbage plants on a slight ridge. This practice is an advantage where tar-pads are used, as the protectors are not liable to become covered with soil.

To secure the greatest benefit the tar papers should be applied immediately after the plants are set in the field. If this work is delayed for several days it gives the flies an opportunity to deposit numerous eggs about the plants.

The method of applying the card is to separate the two edges of the slit running to the center, slip the card around the plant after it is set, and see that it fits snugly about the stem. The paper pad should then be pressed down firmly so that the under surface will be in contact with the soil, and the radial opening closed. (Fig. 23, p. 420.)

In the use of tar-pads the more important points to keep in mind are to set good-sized plants, place them on a ridge rather than in a trench, and attach the tar papers at the time the seedlings are transplanted.

HOW SOD AFFECTED AN APPLE ORCHARD. II.*

F. H. HALL.

Tillage superior to sod mulch.

Five years ago a bulletin of this Station, No. 314, announced that in the Auchter orchard, typical of the great majority of commercial apple orchards of western New York, the tillage-and-cover-crop system of soil management was, in practically every way, superior to the sod-mulch system. Five additional crops have confirmed this conclusion and strengthened the belief that grass roots above apple-tree roots are detrimental to the health of the trees and a menace to good crops.

Under exceptional circumstances, as in the Hitchings orchards, discussed in Bulletin No. 375, deep soils well supplied with moisture may grow both apples and grass successfully and to the financial advantage of the orchardist; but such conditions are so uncommon in commercial orcharding in the great New York apple-belt that the only safe practice is to adopt the tillage-and-cover-crop system unless careful study of all factors has proved sod-mulch better for the particular combination of topographical, soil, labor and market conditions in individual orchards.

Auchter orchard and its management.

The Auchter orchard, in which the experiment here reported was located, is near Rochester, in the heart of the " apple belt " and was chosen because it was uniform in soil and topography and quite typical of the apple orchards of western New York. The land is slightly rolling and is a fertile Dunkirk loam, about ten inches deep, underlaid by a sandy subsoil. The orchard includes nine and one-half acres, set to Baldwin apple trees, 40 feet apart each way, which were 27 years old when the experiment began in 1903. About 120 trees were included in each half of the experiment. On the sections devoted to tillage the land was plowed each spring and cultivated from four to seven times, after which

* Reprint of Popular Edition of Bulletin No. 383; for Bulletin, see p. 529.

a cover crop was sown, usually during the last week in July. During all but the last year of the past five-year period the cover crop has been medium or mammoth red clover, but in 1913 oats were sown. On the sod-mulch plats the orchard grass and blue grass were cut once, sometimes twice, and the crop allowed to lie where it fell. In all other respects except the application of fertilizers in certain sub-sections, the treatment of the plats has been alike and such as prevails in the best commercial orchards.

Experimental conditions and results.

During the first five years of the experiment the orchard was divided into east and west halves for the cultural operations and during the last five years into north and south halves. In this way, at the close of the ten years the northeast quarter of the orchard has been tilled ten years, the northwest quarter in sod five years and then tilled five years, the southwest quarter in sod ten years and the southeast quarter cultivated five years and then in sod five years. About one-half of the area in sod during the last half of the test — a section through the middle of the area — received annual applications of nitrate of soda in an effort to overcome the unfavorable influence of the grass.

In considering results, of course yield comes first, since orcharding is a commercial proposition and upon the amount of fruit harvested must largely depend the income; but in comparing systems where production cost differs as greatly as in sod-mulch and tillage methods of soil management, it is essential to associate these costs with the yields.

The average yield on the plat left in sod for ten years was 69.16 barrels per acre, on the plat tilled for ten years 116.8 barrels, a difference in favor of the tilled plat of 47.64 barrels per acre. These apples were sold at varying prices but averaged $2.60 for barreled stock and 72 cents for evaporator and cider stock, from which sales there was secured an average annual return of $126.04 per acre for the apples grown on sod and of $224.15 from those under tillage. The average acre-cost of growing the apples on sod was $51.73 and under tillage $83.48. Subtracting these figures from the gross return we have a " balance " per acre for the sodded plats of $74.31 and for the tilled plats of $140.67, an increase in favor of tillage of $66.36. For every **dollar** taken from the **sodded** trees, after deducting growing and harvesting expenses, the **tilled** trees gave **one dollar and eighty-nine cents.**

In general quality, also, the fruit from the trees under tillage was much better, being crisper, juicier and of better flavor; and it kept from two to four weeks longer than the fruit from trees in sod. In color, however, the apples grown on sod were superior to those from tilled trees, and they matured from one to three weeks earlier.

The difference in the effect of the two systems on the trees was

almost as great as on the fruit. The trees in sod gained 2.4 inches in tree diameter, taking the average of the measurements, while those under tillage gained an inch and a half more than this, or 3.9 inches. This difference extended in a similar ratio to gain in height and spread of branches; and the foliage of the tilled trees was so much more abundant, and of such dark, rich, green color, that the line between the two plats could be recognized more than half a mile away.

Closer view showed more plainly the sparseness of foliage, irregularity of branches, presence of dead branches and lack of plump, healthy, bright-colored new wood on the trees grown in sod. The trees under tillage, on the other hand, were very uniform in development, with new growth and fruit well and evenly distributed, and notable for their vigor and health.

Change of conditions.

At the close of the first five years one quarter of the orchard was changed from sod to tillage and another quarter from tillage to sod. In each case the effect of the change was almost instantaneous. Before midsummer the trees released from the influence of the sod showed plainly the benefit of the added moisture and available plant food furnished them by tillage. Both trees and foliage improved notably, and the apples on them grew as large as any in the orchard. The number setting was, however, influenced by the previous poor conditions so that the first year's crop was below normal; but the average for the entire five years was as great as that of the trees continuously under tillage. The change for the worse was quite as remarkable and as immediate in the section of the orchard turned from tillage to sod; for the average yield per tree on this section during the first year was less than three-quarters of a barrel, while even the trees continuously in sod yielded twice this amount.

The use of nitrate of soda on the sod helped matters somewhat, and was a paying investment, yet for the whole five years the trees in sod thus fertilized yielded less than half as much as the tilled trees without any fertilizer.

Does tillage exhaust the soil?

Since the trees under tillage have borne heavy crops annually for ten years, without any addition to the soil except the seed of the cover crops used, it might be supposed that the soil would show the draft. Careful analyses made at the close of the test prove that this is not the case. The mineral elements of fertility are practically alike throughout the plats, and the nitrogen and humus are much greater on the tilled plats. Though analyses were not made at the start it is not probable that material differences then existed, for the soil is apparently quite uniform, and previous treatment had been the same for years. It is fair to conclude that the tillage and cover-crop treatment conserves nitrogen and humus

better than the sod-mulch treatment, while it also gives much larger crops.

Why is grass harmful?

Grass in an apple orchard is evidently a detriment, and it acts against the best interests of the trees in several ways. These ways have been so fully discussed in Bulletin No. 314 that it is only necessary to state them here.

(1) The growing grass lowers the water supply, since every plant uses and evaporates many score of times its own weight of water. Under rare conditions this reduction of the water content of the soil might be an advantage to the trees, but in ordinary seasons, on soils neither very deep nor specially retentive of moisture, as in most New York orchards, the trees need all the rain that falls during the growing season, and the draft of the grass roots on the supply of water left near the surface by showers is robbery that affects both the crop of apples and the trees that bear them.

(2) With the water there goes into the grass a certain amount of plant food, which will become available to the tree roots only after a considerable time and some of it probably never. The use of fertilizers in certain portions of the Auchter orchard proved this factor of plant food of less consequence than that of water; yet the trees in sod responded promptly and profitably to applications of nitrate of soda. Trees under tillage, on the other hand, seemed to have enough and to spare of nitrogen, as well as all the other food elements they needed.

(4) The growth of grass on a soil reduces its temperature. Whether this is a serious disadvantage we cannot say, but most New York apple soils are comparatively cold; so it would seem reasonable to suppose any additional cooling influence harmful, as heat causes the food substances in the soil to dissolve more rapidly, hastens their diffusion through the soil water, aids soil ventilation, stimulates the absorptive action of the roots, and helps to form nitrates in the soil. Thermometer readings made over a considerable period showed that the tilled soil in June and July is more than a degree warmer than the sodded soil in the morning and more than two degrees warmer at night.

(5) The supply of air is less in a sodded soil than in a tilled soil; and good soil ventilation is essential not only to the life of the plant itself, but also to the activity of the bacteria which make certain forms of plant food available.

(6) Sod affects deleteriously the beneficial micro-organisms in the soil. The experiment given supplies no definite data to support this statement; but the lowering of the humus content of the soil, restriction of the air supply, cooler temperature and smaller moisture content of the soil under the sod are all factors unfavorable to the development of those bacteria whose action in the soil we know to be beneficial to plants.

(7) Sod may "poison" apple trees. This conclusion has been reached by very careful investigators in England, who assign to this factor, principally, the evil effects which they have found to follow attempts to grow apple trees in sod land. The sudden changes from good to ill results when trees in the Auchter orchard were changed from tillage to sod, and from ill to good when changed from sod to tillage, lend some support to this theory that the grass roots excrete some substance harmful to apple trees; but the other factors previously mentioned, particularly the lowering of the water content of the soil, seem quite sufficient to account for the evil influence of sod without laying much stress upon its excretion of an actual "poison."

Deductions from these tests.

It is hardly necessary to repeat again, or to emphasize the main conclusion from this ten-year test, that tillage and cover crops rather than sod-mulch should be generally adopted by commercial orchardists in New York State.

But some other statements may be made regarding the application of this experiment in other directions.

In orchards on deep soils the sod-mulch method is less of a detriment than on shallow soils. In the deep soil the tree roots have some chance to escape the drought-producing influence of the grass roots. Under some conditions, as where moisture is over abundant and apple trees make too luxuriant growth, sod may occasionally be used with benefit to check growth and promote fruitfulness. There is, however, nothing in the experiment to indicate that on ordinary soils the grass roots and tree roots ever establish amicable relations; for the difference between the tilled and sodded plats was greater at the end of ten years than during the first half of the test. That is, apples do not become adapted to grass. The injurious effects of the grass on apple trees occur, no matter what the variety or age of the tree or other cultural treatment; and are even more liable to be shown by dwarfs than by standard trees because of the shallow root systems of the trees on dwarf stocks. Pasturing orchards in sod may reduce the injury from the grass just to the extent that the pasturing reduces the growth of the grass; but it can never wholly overcome the evil. The owners of sod orchards may not realize how their trees are weakened and their crops lessened by the growth of the grass, since they have no tilled trees under the same conditions to compare with them; but a trained observer can usually detect, even from a distance, signs of poor health and diminished vitality in the light color of the foliage.

The sod-mulch system is bad enough; but grass grown in the orchard, not for a mulch, is all but fatal — it makes the trees sterile and paralyzes their growth. It is the chief cause of unprofitable orchards in New York State.

THE PEAR PSYLLA AND ITS CONTROL.*

F. H. HALL.

A serious pear pest

Probably the most troublesome insect attacking the pear is the psylla. These tiny creatures are similar in many ways to aphids and are sometimes called jumping plant lice. They are sucking insects, like plant lice, and like them, they multiply rapidly, producing several broods each season, so that, unless checked, they make up in numbers what they lack in size, and may injure the pear trees very severely. The larvæ, or nymphs, of the first brood, in early spring cluster about the axils of the leaves or young fruits or work from the under side of the tender young leaves and suck out so much sap that growth is checked just when it should be greatest. The leaves become stunted and sometimes fall, and the fruit ceases to grow in size and may drop prematurely if the work of this first brood is continued by the later broods. In long-continued attacks the trees may become almost defoliated, and the new leaves, if they appear, are generally few in number and pale in color. With the injury caused by the draft on the sap of the tree, there is joined an external disfigurement of both leaves and wood due to the copious secretion of honey-dew by the psylla, which serves as food for the "sooty fungus." Growth of this fungus soon gives the wood a smutty, discolored appearance and darkens and stains the leaves. If the attacks of psylla are severe the trees go into winter in a weakened state and succumb much more readily to low temperatures than do uninjured trees. Renewed attacks, year after year, so lessen the vitality of the trees that they become profitless cumberers of the ground.

Life history of pear psylla

The mature psylla flies (Plate I, fig. 4) of the last fall brood pass the winter on the trees or in protected places about them; and appear not to become completely dormant until permanent low temperatures have been reached. During late November and early December, a rise in the daily mean temperature to only a few degrees

* Reprint of Popular Edition of Bulletin No. 387; for Bulletin see p. 422.

above freezing, especially if the sun shines, will bring the flies from their hiding places under the rough bark or in crevices in it and send them to fruit spurs. With settled cold the flies remain dormant until warm days again occur in late March or early April. They then seek the bud spurs and may remain active continuously if the temperature remains above freezing, or may be chilled into quiescence if the mercury drops again. Soon, however, they mate, and egg-laying begins, the time for this varying with the weather. The dates of the beginning of oviposition for the four years 1910–1913, inclusive, were, in order, April 2, April 14, April 15 and March 21. While egg-laying does not have a very constant relationship to the condition of pear buds, some are always laid before the cluster buds break, and most of them before the tips of these buds have separated. This is an important fact to remember, for it is the index of the proper time to attack the insects — a most essential factor in control measures.

The eggs are orange-yellow in color and very small, so that single ones cannot be distinguished by the eye; but they are often deposited in such numbers that they appear as distinct orange spots or patches. The earliest eggs are laid on the wood, in crevices in the bark around the bases of the blossom buds or on the stems, or in some cases on watersprouts. Oviposition is more often on the under side than on the upper side of the stems and bud spurs. Later, when foliage is unfolded, eggs are laid on the leaves. Egg-laying lasts about two weeks, the time again varying with the weather; and the date of hatching is also dependent on the same factor. Under artificial conditions in the warm laboratory, the larvæ may emerge in eight days, or outdoors, in cool weather, it takes ten days longer; while warm days hasten development. This frequently makes many early-laid and late-laid eggs hatch at the same time, as on April 19, 1910, May 2, 1911, May 4, 1912, and April 10, 1913, when the young larvæ emerged in countless numbers.

The larvæ are quite unlike the adult flies, as shown in Figs. 1 and 2 of Plate I, which represent the five stages of their development, the last being the well-known "hard-shells." These nymphs or larvæ are rather sluggish, wingless creatures quite similar in all stages and always easily identifiable by their bright red eyes. Successive broods of these nymphs emerge about a month apart throughout the summer and continue the harmful work of the first brood.

Remedies suggested.

Of course, spraying is practically the only possible method for controlling the pear psylla — spraying with a contact insecticide, since the insects feed from beneath the surface and cannot, therefore, be poisoned. But the older sprays and methods proposed have not proven thoroughly satisfactory, as these were usually attempts to control the psyllas after the larvæ were present in large numbers on opened buds and developing leaves. The difficulty of

reaching all the tiny creatures at this time with a spray that would be effective and at the same time safe to the tree made it almost impossible to destroy all of the early broods and made repeated treatments necessary — a time-requiring and expensive plan. As far back as 1896, however, Dr. J. B. Smith of the New Jersey Station recommended spring spraying with whale-oil soap just as the buds begin to swell; and in 1899 Prof. Slingerland of Cornell also urged treatment at this time and suggested kerosene emulsion or kerosene and water as applications. In his tests these and other materials for destroying the eggs did not prove successful and, consequently, few attempts have hitherto been made to fight the insect in this stage, as the eggs have been thought quite resistant to any contact insecticide at a strength safe to use on foliage.

The advent of lime-sulphur suggested new possibilities, and tests were accordingly planned by this Station to determine the feasibility of getting rid of the insects in the winter or early-spring stages and to escape, thereby, the difficult task of summer control.

Successful treatments.

These tests have now been continued for four years, and have proved very conclusively that the psylla can be readily controlled by either of two methods, each involving but one treatment, or, at worst, by using both applications. For complete success, however, the treatments must be carefully made, and, particularly for the destruction of eggs and young larvæ in the spring, at just the right time.

The treatments recommended — fall or early spring spraying with nicotine preparations, miscible oils or soapy solutions to kill the hibernating adult flies, and treatment with lime-sulphur just as the cluster buds are beginning to spread, to destroy eggs and emerging nymphs, can be made uniformly successful in isolated orchards, or in communities where all growers unite in the effort. Where adjacent orchards are neglected, however, it may be necessary to make supplementary sprayings to control invaders from such unsprayed plantations.

Fall spraying for adults.

During 1911, experiments were conducted by the Station in the pear orchards of the Middlewood Farms, Varick, N. Y., to test the value of fall spraying to reduce the numbers of overwintering adult psyllas or "flies." The orchard contained 800 Bartlett trees and had suffered severely from psylla injury during the summer. Spraying began on December 6 and continued at intervals, as weather permitted, for ten days, during which period thousands of the insects were clustered on the untreated trees. The insecticides used were tobacco extract, fish-oil soap, and lime-sulphur used separately, and each of the others in combination with the tobacco extract.

The tobacco preparations and the soap solutions proved very effective, but lime-sulphur at the strength for dormant spraying was

not destructive to the "flies" unless combined with the tobacco extract.

On warm days which followed the sprayings few "flies" were detected, and it was estimated that less than five per ct. of them escaped. In the spring so few of the psyllas emerged that no further sprayings were necessary.

Similar experiments in many other pear orchards have been made in the years subsequent to 1911, and wherever weather and other conditions allowed the work to be done thoroughly large percentages of the "flies" have been destroyed by these late fall applications and the insects so reduced in numbers that no further treatments have been needed to control them. Where conditions have been unfavorable for thorough work, or where the psyllas in adjoining orchards were uncontrolled, spring treatments have been found necessary in addition to the fall spraying. The three spray mixtures used—tobacco extract, fish-oil soap and lime-sulphur with tobacco—have been about equally efficient, and perfectly safe to use on the trees. Some orchardists prefer the soap, as it is somewhat less expensive.

Spring spraying for adults.

The fundamental experiments in spring spraying to control the hibernating adults were made in the Collamer orchards at Hilton late in March, 1910. The psyllas were then very numerous in the large orchard of Bartlett, Kieffer and Seckel pears, and 1,530 trees were sprayed either with kerosene emulsion or fish-oil soap. The kerosene emulsion was not effective, possibly because improperly prepared so that the percentages of oil varied on different trees. The fish-oil soap as originally applied, and where used as a supplement to the kerosene emulsion, greatly reduced the severity of the infestation. The following spring another test of this kind was made in the orchard of Mr. L. B. Wright at Hilton, in which about 800 trees were treated with miscible oil or fish-oil soap. The trees in this orchard had been freed from their rough bark, giving less protection to the insects and greater effectiveness to the sprays used. Both applications were successful, the fish-oil soap being rather more satisfactory.

Along the same lines as these two tests cooperative work was carried on with twenty-five pear-growers, in which miscible oils, home-made oil emulsions and soapy sprays were used alone or in combination with tobacco extract. Of these mixtures the soap solutions alone and the tobacco extract with soap were both efficient and safe, but the emulsions were less satisfactory.

Destroying eggs and young larvae.

Psylla eggs have generally been found quite resistant to sprays at any strength safe to use on trees at the stage of growth when the eggs are present. Many different materials and combinations had been used in early tests, but they proved either harmless to the eggs or harmful to the trees.

In lime-sulphur solution, however, a spray seems to have been found both efficient and safe.

In 1910 and 1911 five careful tests were made by the Station in pear orchards near Lockport and Medina, using either the home-made or concentrated lime-sulphur sprays. Both forms of the mixture proved destructive to the eggs or so weakened or repelled the minute nymphs that did hatch that few of them reached the young leaves. Other insecticides used had little or no effect on eggs or young larvæ and could not be counted on to control the pest. The results of these tests are summarized in Table I.

TABLE I.— EFFECT OF VARIOUS INSECTICIDES ON PSYLLA EGGS.

TREATMENT.	Dilution of spray.	Bud spurs counted.	EGGS COUNTED.		Eggs killed.
			Sound.	Col-lapsed.	
					Per ct.
Lime-sulphur.........	(Concentrate 1–8)...	90	39	2,082	98
Lime-sulphur.........	(Concentrate 1–6)...	75	18	339	94
Lime-sulphur.........	(Formula 15–20–50).	102	1,806	564	*24
Fish-oil soap..........	(1–5)..............	100	232	20	8
Kerosene emulsion....	(1–8)..............	100	900	52	5.6
Miscible oil...........	(1–15).............	100	800	45	5.9
Black leaf extract.....	(1–30).............	100	824	64	7.2
	(1–40).............	100	920	48	5
Black leaf 40.........	(1–1000)...........	100	810	61	7
Checks...............	Unsprayed..........	100	2,522	175	7

*The small percentage of eggs destroyed in this test was presumably due to the lower amount of sulphur in solution in the wash.

Cooperative tests in twenty-five other orchards were made in 1911, using lime-sulphur only as this had proved most effective in the preliminary tests. In all cases where care was used to make the treatments thorough and to apply the solution at the right time, practically all of the eggs were destroyed. The owners who were careful were highly pleased with the results of their work and have come to depend almost entirely on this method for controlling the psylla.

To secure these good results it is essential to watch closely the development of the pear buds and spray just when the cluster buds are opening at the tips.

Conclusions. Thus the problem of psylla control is reduced to a comparatively simple one — to make a thorough "clean-up" of the adult "flies" just before they enter or just before they emerge from winter hibernation,

or to destroy the eggs and young larvæ of the first brood while they are still on the branches, stems and fruit spurs or on the unopened cluster buds.

The first treatment is usually the best one to adopt as it so reduces the number of hibernating flies that few eggs are laid the next spring. Then, if lime-sulphur is to be used in the spring for scale, as is the common practice in many large orchards, its application can be postponed a little and the few psylla eggs that are laid be destroyed.

Spraying winter flies.

Especial pains should be taken to destroy the pest in this stage, as effective work greatly reduces the number of eggs deposited on the trees and simplifies subsequent spraying operations. The best means of killing the "flies" is spraying during a period of warm weather, *preferably* in November or December, or during March or early April. A rise in temperature induces the insects to emerge from their hiding quarters and creep to the portions of the trees exposed to the warm rays of the sun and protected from a cold wind. While the insects are able to crawl they are very sluggish in their movements and do not fly. This habit makes them very vulnerable to treatment and the grower should take full advantage of it by so spraying that none of the insects be allowed to escape. To kill the flies it is essential to wet thoroughly all portions of the trees, and especial pains should be taken to force the liquid under loose bark and into all cracks and crevices in the bark. The experiments by this Station have also shown the wisdom of spraying one tree thoroughly before proceeding to another. In balmy weather the flies, like squirrels, may dodge quickly to the opposite side of the tree. By spraying the entire tree they are unable to avoid wetting by the spraying mixture. Treatment late in the fall or early winter is especially recommended as the influence of steadily decreasing temperatures at this season on the movements of the flies makes them especially vulnerable to spraying. In planning for this work select days when there is no danger of the spraying mixture freezing on the trees. The most satisfactory spray from the standpoints of safety to fruit and leaf buds and effectiveness against the insect is three-fourths of a pint of tobacco extract to one hundred gallons of water to which are added from three to five pounds of dissolved soap. (Formula 1.) It is also advisable to remove the loose and rough bark to discourage the flies from wintering on the trees and to render them more exposed to spraying mixtures. This operation may be done at a convenient time but the bark is more easily detached following a wet period. To avoid infection with disease care should be taken not to cut into live tissues.

Fig. 36.— Condition of blossom buds during the spraying for the "flies."

Spraying for eggs of winter flies. The eggs about to hatch and the newly-emerged nymphs succumb to an application of the lime-sulphur mixture. In this lies a hint to the fruit-grower for an effective use of this spray against the psylla as well as the scale. The eggs of the psylla are laid principally during April and commence to hatch early in May or when the blossom cluster-buds are beginning to separate at the tips. (Fig. 25.) Most growers spray much earlier than this for the San Jose scale, but by postponing the treatment of pear orchards until the blossom clusters are well advanced one may deal another effective blow against the psylla and with the same treatment successfully combat the scale. The lime-sulphur solution, testing 32°–34° B., should be diluted in the proportion of one gallon to eight or nine gallons of water. (Formula 4.) The spray should be used in liberal quantities and pains should be exercised to wet all portions of the tree, especially the fruit spurs and the under sides of the young wood, where most of the eggs are laid.

Fig. 25.— Best stage for spraying to destroy psylla eggs.

Spraying for the first-brood nymphs. A third opportunity to strike hard at the psylla is when all of the eggs have hatched and the young nymphs are largely assembled in the axils of the young leaves and fruits. This occurs normally during the latter part of the blossoming period and the young insects can be reached by spraying just as the blossoms drop. The most satisfactory spray is tobacco extract, using three-fourths of a pint to one hundred gallons of water to which are added from three to five pounds of dissolved soap. (Formula 1.)

FIG. 24.—Too early for most effective psylla control.

Late summer spraying. The grower should endeavor to combat the pest by the preceding measures and thus avoid, if possible, the necessity of later spraying. If the trees are badly infested during the summer time it is a very difficult task to bring the pest under

control as there is an intermingling of all stages of the insect, and some of them are resistant to any spraying mixtures which can safely be used on foliage. Moreover the leaves, especially if the growth is heavy, seriously interfere with thorough treatment, and there is also danger that foliage injured by the psylla may be further damaged by the applications of the sprays.

Fig. 37.— Conditions of blossom clusters during the spraying for psylla nymphs.

Frequent and thorough spraying with the tobacco extract (Formula 1), on the first discovery of injurious numbers of the insects is the most satisfactory means of affording protection to the trees.

SPRAYING MIXTURES AND FORMULAS.

Formula 1. Tobacco Extract.

Tobacco extract (40 per ct. nicotine)	$\frac{3}{4}$ pt.
Water	100 gals.
Soap	3 to 5 lbs.

Formula 2. Fish-oil Soap.

Fish-oil soap	20 lbs.
Water	100 gals.

These are recommended for fall or spring spraying to destroy the "flies."

Formula 3. Miscible Oil.

Miscible oil	7–8 gals.
Water	100 gals.

This is a rather dangerous spray and should be used only in the spring as buds are swelling and never after buds begin to show green at the tips.

Formula 4. Lime-Sulphur Mixture.

Lime-sulphur solution (32°–34° B.)	1 gal.
Water	8 to 9 gals.

To be applied just as the blossom cluster-buds separate at the tips to destroy psylla eggs about to hatch and newly-emerged nymphs.

TREE CRICKETS OF GARDEN AND ORCHARD.*

F. H. HALL.

Insect songsters. Undoubtedly many country folk have heard, during the sultry nights of late summer, the shrill, musical trills, or " songs," of tree crickets; but probably only a limited number of nature students have more than wondered who the singers might be. Few persons, indeed, have seen many tree crickets and fewer still realize that there are several species of these interesting little songsters of the night, that they may be both helpful and harmful to fruit-growers, and that they have some most interesting structural peculiarities and habits, unlike those of any other group of insects.

Work of tree crickets. Of these crickets there are three species worthy of some attention from orchardists and gardeners in New York State; but only one that causes serious harm directly by its own work. The other two may even be quite useful at times, and have usually been placed in the category of beneficial insects, as they often feed upon San José scale and other small insects that are distinct menaces to fruit interests. But it is now known that all these species may transport the spores of the fungi that cause certain plant diseases, and that they sometimes deposit these spores where the resultant fungus growth produces cankers and dead areas in bark and wood.

What are tree crickets? Tree crickets belong to the group of straight-winged insects, which includes our common grasshoppers, locusts, katydids and black crickets; but they are smaller, slenderer insects than any of these, and are of a delicate, light yellowish-green color which makes them quite inconspicuous among the foliage of the plants on which they live. Indeed, during the daytime in bright weather, to see them at all, in their five immature stages, it is usually necessary to search very carefully for the very long, slender, forward-stretched antennæ, which the insect extends from within or below some curled leaf or

* Reprint of Popular Edition of Bulletin No. 388; for Bulletin see p. 452.

similar shelter, seemingly to secure warning of the approach of any intruder. Only as evening approaches, or on cloudy days, do the tree crickets become active; for they are essentially nocturnal insects, and feed, sing, mate and lay their eggs mainly in the dusk of evening or at night.

The five immature stages and the adult of one of the tree crickets are shown on Plate XXVIII, and the pictures convey better than can words the general appearance of all the species. There has been considerable confusion as regards both the systematic classification of these tree crickets and the economic importance of the different forms. The studies made at this Station should aid in fixing permanently the distinctions between the three species of economic importance in this State. These species differ mainly in small markings on the antennæ and in the slight variations in size and in the relative length and width of the wings. Imagine the entire insect tinted a light, yellowish-green, more soft and delicate than that of the luna moth, with the abdomen somewhat darker, and the figures on the plate will give a good picture of the tree crickets.

Life history of tree crickets.

The eggs of tree crickets are laid in late summer or early fall in or partly beneath the bark of woody stems, or in the softer pith at the center of the stem of plants like raspberry, elderberry or grape. The female cricket is provided with a delicate but strong ovipositor, a most ingenious boring implement which the insect forces to a considerable depth through bark and soft wood, afterward reaming out the hole until the egg can be passed through the channel to its protected winter home. Not satisfied with depth alone, the mother cricket seals each orifice, either with a pellet of her own excrement deposited for that purpose, or with bark chips which she dislodges, chews up and makes into a ball. The method of sealing with excrement seems to be a peculiarity of one species, the snowy tree cricket, and makes this species doubly liable to be a transmitter of plant diseases; since the spores of fungi have been cultivated in the laboratory from such excrement caps. This species deposits only one egg in a place, on apple frequently selecting a lenticel to lessen the labor of boring out the egg chamber. On trees and bushes with tougher bark the eggs are frequently placed where the bark is thicker and softer, as at the side of buds or small twigs. In raspberry canes the most common place of oviposition is in the fleshy area at the side of the bud in the axil of a leaf, and sometimes an egg may be laid at each side of the bud; but more have never been found in the Station studies.

A closely allied species, the narrow-winged tree cricket, very similar in structure as well as habits, sometimes places two eggs through one opening, but drills two chambers at a slight angle with each other, places an egg in each and then seals the single opening with a bark pellet.

The third species of economic importance, the striped tree cricket, prefers for egg deposition plants with a central pith, like raspberry, blackberry, and certain weeds, while their punctures are common locally in elder, grape, sumac and willow. This species, unlike the others, places its eggs in long rows, one above the other, and the punctures are so numerous that the stems frequently break at the points punctured. This is particularly true of the raspberry, and makes the cricket a pest of serious economic importance under some conditions.

The female cricket may lay from one to a dozen or more eggs in a night and continue the process every night or with occasional intermissions until from twenty-five to seventy-five eggs are laid.

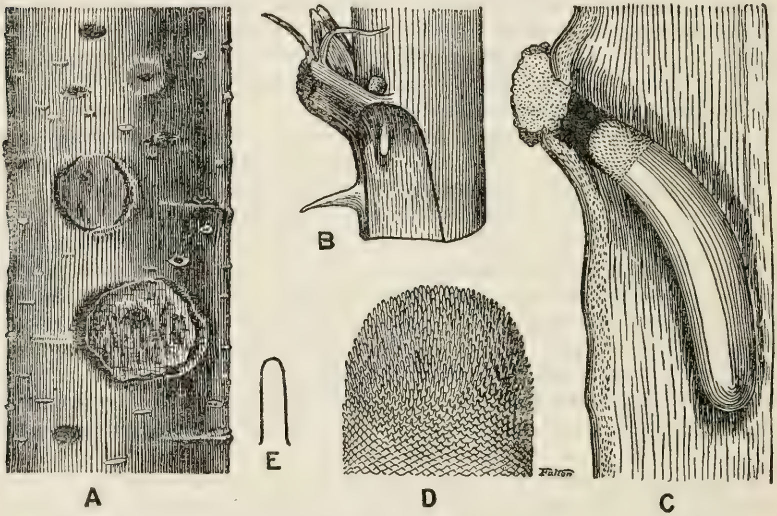

FIG. 31.—SNOWY TREE CRICKET.

a, Egg punctures and cankers in apple wood, ($\times 1\frac{1}{2}$); b, egg in raspberry ($\times 2\frac{1}{2}$); c, egg in apple bark ($\times$ 15); d, egg cap ($\times$ 50); e, spicule of egg cap ($\times$ 500).

The eggs are much longer than wide, are etched over most of the surface with cross-hatched scratches, and each has a cap covered with minute mound-like or teat-like projections. The size and shape of the cap differs with the different species and serves as a means of identification.

The nymphs of the tree crickets begin to emerge from the eggs during early June, and the hatching process is a most interesting one. When the egg hatches, the cap at the outer end breaks off, leaving its trace on the head of the emerging nymph in the shape of

a projecting watery lump which may remain for twenty minutes after the insect has fully emerged.

The young larva assists its own emergence by movements of fore legs and twistings of the body, and when about half out of the orifice pulls its long antennæ out by grasping them with its mouth parts at different points along their length and pulling gently.

Each of the five nymphal stages, or instars, lasts about a week or ten days, with much overlapping of the stages. The change from each stage to the next means a molting of the old skin, and emergence clothed in a new and larger suit. With each change the wing pads become more prominent, but the other variations are inconsiderable, so that the nymphs look very much alike at all stages; but the adults are notably changed by the long, gauzy wings.

The mature forms begin to appear about the first of August and from that time until late in October, their songs may be heard every favorable night.

The cricket songs.

The " song " of the tree cricket is not, of course, a true song, but a more or less musical sound made by the rasping of one wing over the other, the volume being increased by a resonator-like expansion of a portion of the fore wing near the base. In trilling, the wings are raised vertically and vibrated rapidly from side to side, the rasp of the right wing lapping over the scraper-like edge of the left. With the snowy cricket the song is one of the most conspicuous and musical of the common insect sounds of late summer and autumn; a clear, mellow whistle resembling the words *treat, treat, treat*, pitched about in C, two octaves above middle C, on a warm evening rising to D. These clear, high-pitched trills are repeated rhythmically for an indefinite length of time, with considerable variation between individuals in quality, intensity, pitch and rapidity of notes and with a tendency of the insects in a restricted site — a raspberry plantation, clump of bushes or trees or a single tree — to sing in unison.

The song of the narrow-winged tree cricket is about a half tone higher than that of the snowy cricket, about C♯ to D♯ instead of C to D, is not so loud, is longer both in notes and in rests and is not rhythmical in character. Each trill lasts from one to five seconds, but most commonly about two seconds, and the rests vary from one to eight seconds or longer. The song is more mournful in quality than that of its snowy relative, and so much feebler that it is not noticeable without special attention where the two species are in equal numbers.

The striped tree cricket makes a shrill, continuous, *whir-r-r-r-r-r-ring* trill, like the sound of a small tin whistle, continuing sometimes for several minutes. It is much higher in pitch than that either of the other two species — about F♯ on an average summer evening. Unlike the other species it sings in the daytime as well as at night, though the full chorus does not join in until toward evening.

Sex attraction of tree crickets.

Most remarkable of the peculiarities of tree crickets is the fact that the male attracts the female not only by music, but by a feast, both furnished by his own body. When singing, which is evidently to attract the female, the upraised wings disclose upon the body of the male a peculiar rounded depression with elevated margin, which contains numerous hollow glandular hairs, and two paired openings from much branched glands within the fore-body of the insect. The secretion of these glands is eagerly consumed by the female cricket which mounts upon the back of the male and feeds in the depression for several minutes previous to the actual mating, while the crossed antennæ of the pair are touched and rubbed one upon the other in what appear to be mutual caresses.

Economic importance of tree crickets.

Two of the three forms mentioned, the snowy tree cricket and the narrow-winged tree cricket, live quite largely in apple, plum and cherry orchards but are also somewhat common on the raspberries and on walnut. During their early life they are probably beneficial, at least not injurious, as they live to quite an extent on other insects—including even their own weak or disabled relatives. On dissecting several snowy crickets (nymphs of the fourth and fifth instars), the crops of about half of them were found to contain a large proportion of materials of insect origin, while in the others vegetable matter predominated, including leaf tissue and fungous threads and spores.

The insect remains that could be identified were those of their own or their mates' cast-off skins, broken pieces of insects' eyes, probably those of plant lice, and, in practically all cases, portions of the protective coverings and of the bodies of San José scales. In one cricket's crop remains of twenty-four scales were found, with others probably present but not identifiable. This discovery led to an experiment to test the destruction of scales by crickets, and in laboratory tests a single cricket ate from 300 to 900 scales nightly, both covering and insect below. This would indicate that where crickets occur on scale-infested trees they make this pest a considerable part of their diet; yet the scale is constantly spreading in orchards that are well stocked with crickets. They can never be depended upon to control the scale, and if injurious in other ways, as they seem to be, the destruction of the scales should not be allowed to count heavily in their favor.

During the later stages of their lives tree crickets live largely on vegetable tissue; and may do some slight harm by eating holes in leaves. They are also said, in some places, to cause considerable damage by eating holes in fruit, in which they produce a very characteristic injury. The opening through the skin of the peach or plum will be small, just large enough to allow the head and thin

neck to enter, while a considerable cavity may be excavated in the fleshy part of the fruit. These cavities, protected from rapid drying by the small size of the opening, make excellent starting points for fruit rot; so that the initial injury by the cricket is but a small part of the final harm to the fruit. It should be said, however, that such injury to fruits has not been found in New York State, but it is reported to be quite common in Kentucky.

The same small initial injury and considerable attendant damage later result from the oviposition punctures; for these are sometimes followed by slight exudation of sap, with formation of a gummy substance and, particularly on apple trees, open the way for canker-producing fungi. The cankers formed about these punctures are usually small, but they may later be extended by the entrance of other fungi and do much harm to the trees. They also serve as excellent harboring places of the woolly aphis.

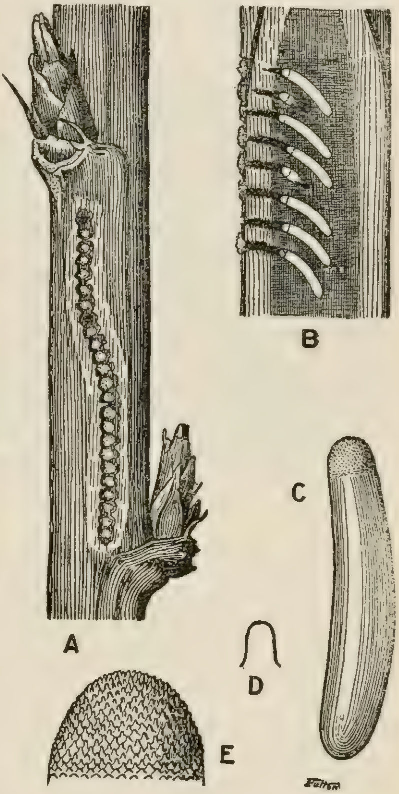

FIG. 34.— STRIPED TREE CRICKET.
a, Egg punctures in raspberry (× $1\frac{1}{2}$); b, Longitudinal section in same (× 3); c, Egg (× 15); d, Egg cap (× 50); e, Spicule of egg cap (× 500).

The possibility of injury from the orchard crickets in these indirect ways probably more than counterbalances the good they may do by destroying scale insects and plant lice. They should not be allowed to increase; but are usually kept well restricted in well-cared for orchards. The freedom of such orchards from some of the favorite weed-hosts of crickets, the pruning and the spraying seem to make conditions unfavorable to their increase; but the exact manner in which these conditions and operations affect the crickets has not been determined.

It is evidently inadvisable to set young apple orchards adjacent to large plantations of raspberries without some precautions against tree crickets; as these insects are usually found most numerous in such localities, both the orchard species and the one which affects the raspberry particularly.

Raspberry tree cricket

This species, the striped tree cricket, must be classed definitely as an injurious species, as it apparently feeds to a much smaller extent on other insects than the other two species, sometimes becomes numerous enough to do quite a little harm to raspberry foliage, and by its punctures so weakens the canes that they break from any unusual strain. In most cases only occasional canes suffer, but in some raspberry plantations, as much as three-fourths of the bearing wood has been found broken from the effect of the punctures or by the development of the raspberry cane blight fungus at these points. Even where the canes do not break, the ready entrance which the punctures offer to this fungus leads to death of the canes, for this disease is one of the most destructive and difficult to control of those affecting the raspberry.

This makes it necessary to restrict the numbers of the striped tree cricket as much as possible; for which the best measures are clean culture, the destruction of weeds in and about raspberry or blackberry plantations, and the removal and burning, during winter and spring pruning, of canes that show tree cricket punctures. Should these measures prove ineffective, it is probable that the crickets can be completely controlled by systematic spraying during July and August with arsenate of lead, three pounds to fifty gallons of water.

"DEAD ARM" OF GRAPE VINES.*

F. H. HALL.

Disease often overlooked. The dead-arm disease of grapes is a widely distributed trouble and in the aggregate does much harm in vineyards of the State. It, however, is not recognized as a disease by most growers; and little or no effort is made to check its spread. The attacks are very slow in developing to the final vine-killing stage and affected plants are usually scattered promiscuously throughout the vineyards, so the work of the disease is easily attributed to accident, winter killing, general lack of vigor, etc., rather than to the true cause, the fungus parasite, *Cryptosporella viticola.*

Yet diseased vines have been found in practically every vineyard examined, the percentage sometimes going as high as 5 per ct. in any particular season, with perhaps as many or more new cases visible the following year. The trouble is found in every grape-growing section of the State, though a cursory examination indicates that it may be less prevalent in the Keuka Lake region than elsewhere.

Symptoms. The most prominent indication of the presence of the disease, at most times in the year, is the dead arm which gives the trouble its name; but another striking symptom, visible only in June and early July, is the peculiar yellow coloration of the foliage and the dwarfing, crimping and curling of the leaves that mark affected portions of the vine. (Plate VI.) The yellowing should attract the attention of every grower during cultivation, and the diseased arm or vine should be removed at once or marked for such treatment at pruning time. There are several other less prominent signs of the disease, which enable the expert to distinguish it from other troubles, but which would not be so quickly noticed by the ordinary vineyardist. These are peculiar, longitudinal, ribbed excrescences on the trunk or arm, dry rot in the heart of the trunk and usually extending to the margin, small reddish brown or black spots on the green shoots, petioles, peduncles and leaf veins, and spotting and rotting of the berries very similar to those produced by black rot.

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* Reprint of Popular Edition of Bulletin No. 389; for Bulletin see p. 251.

Development of the disease. The fungus producing this disease has two fruiting forms, but one of them has not been found in New York State and apparently is not essential to the indefinite continuation of the life of the parasite. The pycnidia, or spore-containers, of the fungus stage found in this State are minute flask-shaped bodies, occurring usually in the bark of one or two previous seasons' growth, which raise the corky layer of the bark, and form the tiny pustule-like spots shown in Plate VIII. A drawing of one of these pycnidia, greatly magnified, is shown on the title page. These are found in greatest abundance in early spring, and each ruptures and pours out its accumulation of spores shortly after the bursting of the grape buds. The spores seem to be embedded in a mucilaginous material which swells greatly when it absorbs moisture and forces itself and the spores from the pycnidium in a striking, reddish yellow ball or curl. These spores may be carried to young shoots a few feet away by spattering drops of rain, or may be washed to shoots immediately below, but most of them pass to the ground and perish.

The spores find favorable conditions for germination in the clinging drops of water which persist on the shoots for many hours during continued fog and rain, such as often prevail in both the Chautauqua and Central Lakes regions late in May. After the germ tube enters the interior of the shoot, about a month usually elapses before the disease shows externally, but by the first of July lesions appear. These are generally found only at the bases of the shoots, indicating that but one period of infection occurs each year. This spore infection of the new shoots was formerly thought to be of minor importance in the spread of the disease, as compared with inoculation from the saw and other pruning tools previously used on diseased vines, since these agencies may transfer the parasite directly to the arm which it will destroy, while infection of the arm from the shoots is indirect. If only a few spots are produced on the shoot, the resulting cane may bear a crop the succeeding year and be removed before the fungus has had an opportunity to grow down into the more permanent part . On the other hand, if the infections are numerous there is a possibility in case the cane is saved for bearing wood that marked symptoms of the disease will develop during the bearing period of the cane, and at all events the probability of the fungus gaining entrance into the arm is greatly increased. Infection through tools used in pruning has been proved possible by many successful inoculations made in this way, and is probably a common means of spreading the disease. Spread through purchase of infected nursery stock is possible, but tests made indicate that under most conditions vines started from infected cuttings will not survive to reach the grower. If the cuttings are made from canes only slightly infected, though, it is quite probable that the cuttings would make vines that could be sold and

that might grow for several years without showing marked evidences of disease. Development of the disease is slow, so that infected arms or vines may live four, five or even more years, but with a constantly increasing loss of vitality. Under such conditions any severe strain on the vine, like a particularly hard winter, may result in its death; and while the vine still lives the yields of the whole plant or of the affected arm are reduced below the profitable point. Such vines or arms should be hunted out and removed, and new healthy wood be secured to take the place of that diseased.

Remedy. This is not difficult, for the new growth from near the ground or below its surface, even on a badly infected vine, is usually free from the disease, and can be kept so if the affected portions of the vine and adjacent ones are promptly and thoroughly removed.

The remedy for the disease is therefore quite simple: The diseased vines should be marked in early summer, when they are easily recognizable from the yellow leaves, and all affected wood removed and burned. By carrying a piece of old cotton or linen cloth when cultivating the vineyard, it is but the work of seconds to attach to the diseased vine a strip of cloth to direct attention to it when trimming. Often the removal of a single arm eradicates the disease, but in other cases the whole trunk will be found affected. If the characteristic discoloration or dry rot of the wood of the main trunk is apparent the whole vine should be sawed off at a point below the last indications of rot. In many cases it will be best to cut the vine off close to the ground so that renewals will come from below the surface. If all sources of infection are removed, such renewals are sure to be healthy and to develop rapidly into strong vines. In some years it might be safe to leave infected wood to bear fruit while the renewal canes are growing, but when conditions are favorable for infection such a procedure would be very unwise. In any case each renewal should be inspected carefully some time during late summer to see that it has not been infected; for if it has been attacked by the fungus, even slightly, it should be rejected. To insure one healthy renewal it is well to leave two or three suckers at the base of the stump from which to select when tying up. At the regular trimming time precaution should be made not to leave for bearing wood any canes that show lesions of the disease. Detection of these is easy with a little care, as they are usually conspicuous at this time, being reddish in color and slightly elevated.

Spraying should be effective in preventing the spread of this disease, and where black rot is prevalent the first application for this disease, when the shoots are eight or ten inches long, should protect these shoots from infection with the dead-arm fungus. Where growers realize the necessity of spraying to control root worm, and own spraying machines for this work, the use of an early application of bordeaux to assist in eradicating the dead-arm disease would be well worth while.

RINGING AN UNSAFE STIMULUS TO FRUIT-BEARING.*

F. H. HALL.

A dangerous remedy.

Sluggish fruit trees sometimes so tax the patience of their owners that any measure would be adopted, however drastic, if it promised to spur the laggards into fruitfulness. For this reason the practice of ringing trees and plants has occasionally, for a hundred years or more, been recommended by plant physiologists and used by growers to induce or to increase fruit-bearing. The method has a theoretical chance for success; since the removal of a ring of bark from tree trunk or plant stem may be made with comparative safety at a certain time in the season and does not seriously interfere with the upward circulation through the active, growing, new wood, but does prevent the downward flow of the sap with the plant food formed in the leaves. Thus the food for the whole plant, including the lower stem and roots, is concentrated in the parts above the ring, and should and does serve as a stimulus to the formation and development of fruit buds. But is this stoppage of the normal circulation without danger to the plant, or is the good great enough to overbalance any such danger? Only careful experiments, continued for some time, can answer these queries satisfactorily; and such tests, made at this Station, prove that the practice is generally either of too slight advantage to pay for itself or too dangerous to justify its use even when immediate results seem favorable.

Tests reported in Bulletin No. 151 of the Station prove that ringing grape vines of certain varieties produces earlier ripening and better clusters, but that the vines suffer severely and do not become normally vigorous again for a long time, if ever. Bulletin No. 288 reports ringing of herbaceous plants, like tomatoes and chrysanthemums, as detrimental to the plants and productive of no compensating results in earlier or better fruits. The present bulletin records tests of ringing on apple, pear, plum and cherry trees, which indicate very limited advantage for the practice under any conditions and decided disadvantages in most cases, particularly with the stone fruits.

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* A reprint of Popular Edition of Bulletin No. 391; for Bulletin see p. 613.

Ringing apple trees.

In June, 1910, a ring of bark one inch wide was removed from the trunk of each of 122 seedling apple trees then five years from planting. The bark was taken just above the surface of the ground, and left in each case a clean surface of succulent, active cambium (new wood) which began immediately to repair the wound, so that by the end of the season all the rings were entirely covered with new, healthy bark. The trees were exceptionally strong and vigorous to start with and probably in better condition to withstand ringing than average orchard trees. None of them showed any set-back from the operation. During this season no effect on the fruit could be expected, except some slight increase in size of the apples already set, but notes were taken on the crop as a check upon the effects of the ringing, if any, upon the number of trees fruiting and of fruits setting upon the individual trees in 1911. The results appear to favor ringing; since twice as many trees set fruit in 1911 as in 1910 (107 and 54, respectively), and the bearing trees produced 56 per ct. of a full crop in 1911 as compared with 7 per ct. in 1910. Of course, some of this increase was due to the advancing maturity of the trees, but it is evident that ringing these young, healthy, vigorous trees stimulated fruit production. The trees, however, never bore so good a crop again, even though subsequently ringed. In 1911, 27 of them were ringed a second time by removing inch strips directly above the former rings, again with quick healing and no apparent ill effects. But these trees ringed a second time averaged considerably less than half as good crops in 1912 as in 1911, and did no better than the trees ringed only in 1910.

In 1912, wider bands were removed from these same trees, the rings ranging from three to twenty-one inches on groups of four trees each. This severe treatment had no effect in stimulating fruit production, but an exhausting effect upon the trees, which increased with the width of the ring. One tree in both the three-inch-ring group and six-inch-ring group died after ringing, and from one to three trees in each of the other groups were lessened in vigor.

In 1911, Baldwin trees three years from setting were ringed, in groups of five trees each, beginning with two-inch strips and increasing the width of the band by two inches for each succeeding group until twenty inches was reached. At the same time the bark was removed from similar groups of trees in inch rings at varying distances from the ground, up to two feet. These young trees suffered severely from the ringing, as new bark was not formed rapidly enough to cover the wound in any tree by the close of the season. The foliage dropped very early on all the trees, several died, all showed lack of vigor, and only 10 per ct. of them started into growth the following season. Tests made the next year, with trees four years set, removing only one-inch rings, resulted about the same; as the ringed trees made less

growth than similar trees not ringed, dropped their foliage early and made less growth, particularly of roots.

From these experiments it is clear that the first ringing of seedlings influenced fruitfulness favorably and resulted in a good setting of fruit without noticeable injury to the trees, but that subsequent ringing did not produce similar effects. With the Baldwins the results were all unfavorable to the practice.

Ringing other fruits. On young Bartlett pear trees ringed in 1912 by inch bands, the formation of new bark was not satisfactory; and before the end of the next season half of the ringed trees were dead and the others had made such poor growth that they were discarded. Digging showed the root systems to be very poorly developed.

Ringing is very seldom recommended for stone fruits; as trees of this kind usually come into bearing earlier than apples and pears; are not as hardy, are less resistant to external injuries and are shorter lived. Nevertheless, some tests of the practice were made on both plums and cherries, with even less satisfactory results than with the pears. Few of the wounds healed perfectly, the foliage lost color and dropped early, growth was stunted, and of all the trees treated only one Montmorency cherry made any material growth the following season. Where any fruit set, as it did on a few of the plum trees, the ringing led to no increase in quantity, and to some decline in quality.

Conclusions. " The results obtained from these experiments are not favorable to ringing fruit trees as a general practice. Under some conditions, for a limited time, a more favorable outcome might be expected. Hardy, vigorous, young apple trees may readily undergo a single ringing and be benefited thereby, but subsequent operations are injurious. Trees lacking vigor are often seriously injured by the practice. The deleterious effects of the treatment have generally been so marked upon various plant organs as to render the operation exceedingly hazardous. There seems to be no regular or systematic increase in fruit production. The gains do not offset the losses."

FERTILIZER FACTS FOR FARMERS.*

F. H. HALL.

Possible economies in buying fertilizers. Fertilizer users in New York State might save thousands of dollars by wiser selection in their purchases of such materials. First, they might easily gain by buying fertilizer ingredients and mixing them at home; since nitrogen, phosphoric acid and potash sell at much lower rates in unmixed materials than in " complete " fertilizers of any grade, as both are quoted in ordinary retail trade. Second, there are quite wide differences in the prices of nitrogen, phosphoric acid and potash in the various unmixed materials which furnish these elements; and careful study of the materials on the market would lead to considerable saving through choice of the cheaper instead of the more expensive sources of the elements of plant food in separate form. Third, and probably most applicable in the great majority of fertilizer purchases, the selection of high-grade instead of low-grade " complete " fertilizers would secure the plant food elements more economically.

These facts, with others of interest, are shown by a study of the composition and prices of different brands of fertilizers and fertilizer materials on the market in New York State. The analyses of more than 1000 brands of such goods are shown in Bulletin 390 of this Station. The selling prices were secured by the collecting agents of the State Department of Agriculture and furnished the Station by the Commissioner, these being the ordinary retail prices of dealers who sell to farmers in comparatively small lots. Associations of farmers, buying in large quantities for cash, secure their plant food at lower prices than prevail in the usual retail trade.

Cheapest source of elements. The average price of nitrogen in 600 brands of " complete " fertilizers of all grades, of which samples were analyzed, was 27.0 cents a pound; but in unmixed materials of whatever kind, except commercial dried sheep manure, it was from 2½ to 9 cents a pound lower. Even in the highest grade of mixed goods the average cost of the nitrogen was 24.2 cents a pound, while in meat and bone tankage it was only 22 cents, in dried blood only 21.6 cents and in nitrate of soda, the cheapest source of nitrogen, only 17.8 cents. By far the most expensive nitrogen furnisher, however, was the sheep manure, recently so widely and extravagantly advertised, in which the element cost

*A reprint of Popular Edition of Bulletin No. 392; for Bulletin see p. 649.

69 cents a pound, or more than three times its ordinary commercial valuation. This same sheep manure was, also, with the exception of wood ashes, the most expensive source of phosphoric acid or of potash. If such prices are asked for this material, no intelligent user of plant foods should give it a moment's consideration.

For phosphoric acid, in readily available form, acid phosphate is the cheapest source, and wood ashes the most expensive, the phosphorus costing four times as much in the ashes as in dissolved rock. The best grade of mixed goods approaches reasonably close to the acid phosphate as an economical source of supply, the difference being less than half a cent a pound, but in complete fertilizers of lower grade the cost per unit rapidly increases so that in low-grade goods the phosphoric acid costs 20 per ct. more than in acid rock. For somewhat slower-acting phosphoric acid, tankage and fish scrap show good value. At the price quoted for the four samples collected, $13 a ton, ground rock phosphate or floats is not considered an economical source of phosphoric acid. At $8.50 a ton, at which price it is known some goods have been sold, the insoluble phosphoric acid would cost about 1.4 cents a pound. This is less than its commercial valuation in mixed fertilizers.

Potash, at the prices prevailing during the first half of 1914, could be obtained cheapest in muriate, at an average price of 4.7 cents a pound, in kainit it cost 5.4 cents, in high-grade mixed goods, 5.6 cents and in sulphate, 5.7 cents. In the lower grade mixed fertilizers it cost 6.8 cents, or 44 per ct. more than in the muriate. In wood ashes, however, the price broke the record for fictitious valuation, reaching the limit of 30 cents a pound, or an increase of almost 540 per ct. above what potash could be obtained for in its cheapest form. The lime content of ashes has not been considered in making these computations. Using the value of this element would lower prices of phosphoric acid and potash somewhat. Of course, the war has so changed the potash situation that these figures are not applicable at present.

All mixed fertilizers expensive.

The comparisons just given show that with the exception of a few materials, like sheep manure and wood ashes, whose value has been greatly overestimated in popular opinion, the three elements of plant food most commonly considered can be obtained cheapest in comparatively simple chemicals or other natural compounds; that is, in unmixed form. For example, the average cost of nitrogen, in all the simple or natural sources of supply examined, except sheep manure, was 22 cents a pound, in complete fertilizers of high grade 24.2 cents, in those of low grade 32.5, in those of all grades, averaged, 27 cents; and in the so-called bone and potash mixtures 33.5 cents.

Similarly, phosphoric acid in unmixed goods, except floats, sheep manure and ashes, could be secured at an average cost of $4\frac{2}{3}$ cents

a pound. The average cost in complete fertilizers was 5.9; and in special mixtures like phosphate and potash, bone and potash, lime, phosphate and potash, etc., the average cost was 6½ cents.

Potash in potash salts cost 5.3 cents; when combined with the other two elements in complete fertilizers, its price, averaging all brands, was 6.2 cents; and in special combinations 6.3 cents.

It will thus be plainly seen that the plant food elements in unmixed chemicals, etc., are obtainable, even in local markets, at prices decidedly below those prevailing for the same elements in ready mixed form. In hundreds of cases, these materials could undoubtedly be mixed at home at a cost far less than the difference between their price and that of the same amount of each element in some manufacturer's combination with a fancy name. With study of farm conditions, also, it would certainly be found in many instances that a single element or a comparatively inexpensive home-mixture of two of them would give as good results on a particular field or for a specified crop as any brand of "complete" fertilizer on the market.

High grade fertilizers best value.

But most users of plant food will, without doubt, in the future as in the past, buy ready-mixed fertilizers rather than purchase the ingredients and mix them at home. Yet economy is possible, even in buying complete fertilizers; for the figures of composition and prices show that high-grade goods give by far the best value for the money invested. The plant growers of the State pay about $5,000,000 a year for fertilizers — mainly mixed goods; but only one-fourth of the brands of fertilizers offered for sale in the State in 1914, and certainly less than one-fourth of the quantity of goods sold, were "high-grade"; that is, contained plant food elements with a commercial valuation greater than $25 a ton.

It is evident that, far more often than not, the buyers of fertilizers select brands that supply the plant food they desire at prices much above what they need pay.

The average selling price of the low-grade to medium high-grade goods was $26.45 a ton, which was $8.66, or 48 per ct., above the average retail value, in the large markets, of their plant food constituents; while the average price of the high-grade goods was $34.77, which was only $6.62, or 23 per ct., above the commercial valuation of their ingredients. That is, the purchasers of high-grade goods paid out less than one-fifth of their money (19 per ct.) for freight, distribution expenses, etc., while those who bought goods of lower grade gave almost one-third (32 per ct.) of what they spent, for something outside the commercial valuation of the plant food secured. The buyers of "low-grade" goods (commercial valuation less than $16 a ton) paid $22.98 for goods whose plant food value, on the regular basis was $13.74; therefore they devoted $9.24 a ton, or 40 per ct. of what they spent, to the incidental expenses of the fertilizer traffic.

TABLE I.—COST OF ONE POUND OF PLANT-FOOD TO FARMERS.

	Highest.	Lowest.	Average.
Nitrogen in	*Cents.*	*Cents.*	*Cents.*
Low-grade complete fertilizers	42.5	22.0	32.5
Medium-grade complete fertilizers	45.8	19.5	28.9
Medium high-grade complete fertilizers	44.2	19.5	26.9
High-grade complete fertilizers	33.0	15.8	24.2
Average of all complete fertilizers	....	....	27.0
Bone and potash mixtures	63.2	27.1	33.5
Bone-meal, etc	36.1	17.2	24.5
Tankage (meat and bone)	26.0	13.4	22.0
Tankage (meat)	28.0	20.7	24.4
Dried blood	23.8	19.4	21.6
Sodium nitrate	21.0	16.0	17.8
Commercial dried sheep manure	107.0	43.0	69.0
Fish-scrap	24.0	21.4	22.5
Phosphoric Acid in			
Low-grade complete fertilizers	9.3	4.8	7.1
Medium-grade complete fertilizers	10.0	4.2	6.3
Medium high-grade complete fertilizers	9.6	4.2	5.9
High-grade complete fertilizers	7.2	3.4	5.3
Average of all complete fertilizers	....	....	5.9
Acid phosphate and potash mixtures	9.1	4.3	5.6
Bone and potash mixtures	11.8	5.0	6.2
Acid phosphate (dissolved rock)	8.3	3.5	4.95
Bone-meal, etc	6.7	3.2	4.6
Tankage	4.8	2.5	4.1
Commercial dried sheep manure	20.0	8.0	10.0
Wood-ashes	21.7	20.3	21.0
Fish-scrap	4.3	3.8	4.1
Basic-slag phosphate	6.1	5.0	5.6
Ground rock-phosphate (floats) — insoluble	1.9	2.2	2.1
Mixtures of compounds of calcium, phosphoric acid and potash	12.0	4.0	7.6
Potash in			
Low-grade complete fertilizers	9.8	5.1	7.5
Medium-grade complete fertilizers	10.6	4.5	6.7
Medium high-grade complete fertilizers	9.7	4.5	6.2
High-grade complete fertilizers	7.7	3.6	5.6
Average of all complete fertilizers	....	....	6.2
Acid phosphate and potash mixtures	9.6	4.6	5.9
Bone and potash mixtures	12.5	5.3	6.7
Muriate (potassium chloride)	5.6	4.0	4.7
Sulphate (potassium sulphate)	6.0	5.5	5.7
Kainit (low-grade potassium chloride)	7.0	4.4	5.4
Commercial dried sheep manure	69.0	13.0	16.0
Wood-ashes	31.0	29.0	30.0
Mixtures of compounds of calcium, phosphoric acid and potash	12.0	5.4	7.6
Calcium and Magnesium in			
Calcium carbonate (ground limestone, marl, etc.)	0.95	0.50	0.72
Calcium hydroxide (slaked or hydrated lime)	0.73	0.55	0.65
Calcium oxide (quicklime, burned lime, etc.)	0.65	0.40	0.52
Mixtures of compounds of calcium, phosphoric acid, etc	1.50	0.70	0.95

If all the purchasers of lower grade fertilizers had judged brands and values wisely, they might have saved themselves at least $500,000 in 1914; since the lower-grade brands cost at least that sum more than would high-grade goods of the same value as measured by the retail price, in the large markets, of the fertilizer elements they carried.

It should be noted in this connection, however, that the high-grade fertilizers are higher priced, as a rule, because they contain larger proportions of nitrogen than do goods of lower grade, and nitrogen is the most expensive element in fertilizers. To those growers, therefore, who know they do not need much nitrogen, the purchase of complete fertilizers of the highest grade might not be advisable, as the waste of nitrogen might easily overbalance the gain from better prices for the other ingredients. In such cases, brands of lower grade should be selected, in which the proportion of nitrogen is less, but in which the selling price is still not unreasonably above the commercial valuation of the ingredients. Such brands may be found in every grade. Even in the lowest grade goods, one brand was found whose selling price was only $2.03 above its commercial valuation; in medium-grade goods one fertilizer carried ingredients whose commercial valuation was equal to the selling price of the brand; and in medium high-grade goods one brand was found whose selling price and commercial valuation differed by only 10 cents.

To sum it all up, the lesson of the figures is that careful study of fertilizer values will result in saving to the purchaser. That such study is being given by many farmers is shown by the fact that in 1902 69 per ct. of the brands on the market were "complete" fertilizers, in 1914 only 61 per ct.; in 1902 only 17 per ct. of the brands offered were high-grade goods, while in 1914, 26.1 per ct. belonged in that class. Rather slow progress, however, when the chances for saving are so evident!

Inspection shows good conditions.

In making the comparisons of brands, buyers can, in most instances, depend upon the manufacturer's guaranty, since in only 27 brands of complete fertilizers out of 614 examined was the deficiency of elements great enough to make the sale of the brand a violation of the present fertilizer law; and of special mixtures and unmixed materials only 7 samples out of 390 examined showed sufficient deficiency to class them as violations. Balancing all excesses and deficiencies it is shown that the manufacturers of complete fertilizers gave fertilizer elements worth about $1.08 a ton more than their guaranties demanded, there being an average excess of 0.08 per ct. of nitrogen, 0.44 per ct. of available phosphoric acid and 0.34 per ct. of potash. In general, therefore, the manufacturers' guaranties, especially if backed by good reports in inspection bulletins of recent years, may be taken as safe guides in computing the relative value of the brands, using the figures for the

commercial value of the ingredients given in the present or past season's "Fertilizer Bulletin."

In individual instances, however, brands fell considerably below guaranty; so that the purchaser of dried blood from one lot sampled would have received $3.69 less plant food than was guaranteed; one lot of muriate of potash was worth $3.90 less than its guaranty called for; one of ground fish $4.13 less than the guaranty; and one of tankage $6.90 less than its supposed content of nitrogen and phosphoric acid. The brands of calcium-containing materials apparently fell below legal requirements as a class, and some really were poor value for the money invested, but in other cases the content of magnesium was great enough to make the lime compound fully as efficient in sweetening the soil as the guaranty would indicate; for magnesium, though not specified as an ingredient to be guaranteed, is even more valuable than lime, pound for pound, in correcting soil acidity.

Sodium nitrate, basic slag, floats, sulphate of potash, kainit and bone and potash mixtures held well up to their guarantees; but acid phosphate, muriate of potash, bone, tankage, sheep manure, mixtures of acid phosphate and potash, and wood ashes fell below their guarantees in too many instances to be thoroughly satisfactory from the purchaser's standpoint.

Change in law a loss to farmer in some cases.

Previous to 1910 the fertilizer law made it a violation if the goods fell below the guaranty for any element by a fixed amount (one-third of one per ct. for nitrogen, or one-half of one per ct. for phosphoric acid or potash) without allowance for any excess that might exist in other elements. This was felt to be unfair in two respects: It made the maker of high-grade goods liable to penalty for a much smaller proportionate deficiency in his goods than the maker of low-grade brands; and it might frequently punish the manufacturer who really gave far more plant food value in two elements than the brand was short in the third ingredient. In attempting to remedy these defects the law was changed in 1910 to allow deficiencies, up to a certain limit, to be balanced by excesses in other elements; and to subject the manufacturer of a brand to prosecution for proportionate rather than fixed deficiencies. By the new law, a deficiency up to 10 per ct. of any element is allowed without penalty; and up to 20 per ct. if the monetary value of the deficiency is made up by an excess of one or both of the other elements. With many brands this law is to the advantage of the consumer; with others, it may be decidedly to his disadvantage, and allow deliberate over-guaranty of goods without replacement by a financial equivalent and without legal penalty.

In low-grade goods, those in which the guaranties are not above 3.3 per ct. of nitrogen and 5 per ct. of phosphoric acid or of potash,

this law favors the purchaser, since the deficiencies allowed without penalty are less than under the old law. With goods of higher grade than this, on the other hand, the advantage is with the manufacturer, and increasingly so the higher the guaranty of the goods.

For example, nitrate of soda is usually guaranteed at about 15 per ct. nitrogen, on which the law allows a deficiency of 1.5 per ct., or 30 pounds of nitrogen to the ton, selling at from 16 to 21 cents a pound in different localities; in 16 per ct. acid phosphate the allowable deficiency might cost the purchaser from $1.10 to $2.65 a ton; while in muriate of potash guaranteed at 49 per ct. potash, the deficiency might, without penalty, lose the purchaser about 98 pounds of potash in a ton; that is, from $3.90 to $5.45, according to what he would have paid for the goods at spring prices of 1914

In complete fertilizers, taking the analyses of eight brands below guaranty, the actual deficiencies, measured by the commercial valuation of the elements, were worth from $1.78 to $4.81 a ton; and in ten cases of fertilizing materials the absent plant food had a retail market value ranging from $1.69 to $4.57. Of course purchasers of such goods lost more than this; for in almost no instance did they get the ingredients for their commercial valuation.

In general it may be said that, under the present law only 34 violations were found in 1004 samples examined; while under the old law 105 of the samples would have fallen below their guaranties enough to class them as violations.

Remedy for defects in law.

The *possibility* for injustice to the farmer, therefore, is considerable under the present law; and it would seem very desirable to provide a remedy if one can be found that will not be unfair to the manufacturer. Such a remedy appears to lie in fixing a limit beyond which the 10 per ct. deficiency provision shall not hold. The Station would suggest amendment of the law by inserting in it the words: " and provided further that when such ten percentum deficiency amounts to more than three-tenths of one pound of nitrogen or one pound of phosphoric acid or of potash in one hundred pounds of fertilizer or material to be used as fertilizer, it shall be a violation unless there be a monetary equivalent in excesses in other guaranteed constituents as provided herein."

PERIODICALS RECEIVED BY THE STATION.

Acclimitation	Complimentary
Agricultural Epitomist	Complimentary
Agricultural Gazette of New South Wales	Complimentary
Agricultural Journal, China	Complimentary
Agricultural Journal of the Union of South Africa	Complimentary
Agricultural News	Complimentary
Agricultural Students' Gazette	Complimentary
Allegan Gazette	Complimentary
American Agriculturist	Subscription
American Breeder	Complimentary
American Chemical Society Journal	Subscription
American Cultivator	Complimentary
American Entomological Society, Transactions	Subscription
American Fertilizer	Subscription
American Florist	Subscription
American Grocer	Complimentary
American Hay, Flour and Feed Journal	Complimentary
American Journal of Physiology	Subscription
American Miller	Complimentary
American Naturalist	Subscription
American Philosophical Society, Proceedings	Complimentary
American Poultry Advocate	Complimentary
Analyst	Subscription
Annales de l'Institut Pasteur	Subscription
Annales de la Societe Entomologique de Belgique	Complimentary
Annales Mycologici	Subscription
Annals and Magazine of Natural History	Subscription
Annals of Botany	Subscription
Archiv der Gesammte Physiologie (Pflueger)	Subscription
Archiv fuer Hygiene	Subscription
Association belge des Chimistes, Bulletin	Complimentary
Berichte der deutschen botanischen Gessellschaft	Subscription
Berichte der deutschen chemischen Gessellschaft	Subscription
Better Fruit	Complimentary
Bibliographia Zoologica	Subscription
Biedermann's Zentralblatt fuer Agrikultur Chemie	Subscription
Biochemical Bulletin	Complimentary
Biochemische Zeitschrift	Subscription
Biological Bulletin	Subscription
Biologisches Centralblatt	Subscription
Blooded Stock	Complimentary

Boletim de Agricultura	Complimentary
Boletim do Instituto Agronomico	Complimentary
Boletin de la Sociedad Nacional de Agricultura	Complimentary
Boston Society of Natural History, Proceedings	Complimentary
Botanical Gazette	Subscription
Botanisches Centralblatt	Subscription
Bulletin de l'Institut Pasteur	Subscription
Bulletin fuer Angewandte Botanik	Subscription
Caledonia Era	Complimentary
California Academy of Sciences, Proceedings	Complimentary
California Cultivator	Complimentary
California Farmer	Complimentary
California Fruit News	Subscription
California University Publications — Agricultural Sciences, Botany and Zoology	Complimentary
Canadian Entomologist	Subscription
Canadian Horticulturist	Complimentary
Centralblatt fuer Bakteriologie, etc.	Subscription
Chemical Abstracts	Subscription
Chemical Society, Journal	Subscription
Chemisches Centralblatt	Subscription
Chicago Daily Farmers' and Drovers' Journal	Complimentary
Chicago Dairy Produce	Complimentary
Cincinnati Weekly Enquirer	Complimentary
Cold Storage and Ice Trades Review	Complimentary
Colman's Rural World	Complimentary
Colonial Dairy Produce Report	Complimentary
Columbus Horticultural Society Journal	Complimentary
Commercial Poultry	Complimentary
Country Gentleman	Subscription
Country Life in America	Subscription
Country World	Complimentary
Creamery and Milk Plant Monthly	Complimentary
Criador Paulista	Complimentary
Dairy and Produce Review	Complimentary
Denver Field and Farm	Complimentary
Deutsche Entomologische Zeitschrift	Complimentary
Deutschlands Obstsorten	Subscription
Dry Farming	Subscription
Elgin Dairy Report	Complimentary
Entomological News	Subscription
Entomological Society of America, Annals	Subscription
Entomological Society of Washington, Proceedings	Subscription
Entomologist	Subscription
Entomologists' Record	Subscription
Farm and Fireside	Complimentary

Farm and Live Stock Journal	Complimentary
Farm and Orchard	Complimentary
Farm and Stock	Complimentary
Farm Engineering	Complimentary
Farm Journal	Complimentary
Farm Life	Complimentary
Farm News	Complimentary
Farm Poultry	Complimentary
Farm, Stock and Home	Complimentary
Farm Stock Success	Complimentary
Farmers' Advocate	Complimentary
Farmers' Digest	Complimentary
Farmers' Guide	Complimentary
Farmers' Voice	Complimentary
Farmer's Wife	Complimentary
Feather	Subscription
Feathered World	Subscription
Field, The, Illustrated	Complimentary
Florists' Exchange	Subscription
Flour and Feed	Complimentary
Fruit Grower	Complimentary
Garden	Subscription
Gardeners' Chronicle	Subscription
Gartenwelt	Subscription
Gas and Oil Power	Complimentary
Gleanings in Bee Culture	Complimentary
Grape Belt, The	Complimentary
Green's Fruit Grower	Complimentary
Hartwick Seminary Monthly	Complimentary
Harvester World	Complimentary
Hawaiian Forester and Agriculturist	Complimentary
Hedwigia	Subscription
Herd Register	Complimentary
Herkimer County News	Complimentary
Hoard's Dairyman	Complimentary
Holstein-Friesian Register	Complimentary
Holstein-Friesian World	Complimentary
Homestead	Complimentary
Hospodar	Complimentary
Hygienische Rundschau	Subscription
Indiana Farmer	Complimentary
Insect World (Japanese)	Complimentary
Internationale Mitteilungen fuer Bodenkunde	Subscription
Jahresbericht der Agrikultur-Chemie	Subscription
Jahresbericht Garungs-Organismen	Subscription
Jahresbericht der Nahrungs-und Genussmittel	Subscription

Jahresbericht Pflanzenkrankheiten	Subscription
Jahresbericht der Tier-Chemie	Subscription
Journal fuer Landwirtschaft	Subscription
Journal of Agricultural Research	Complimentary
Journal of Agricultural Science	Subscription
Journal of Agriculture, Victoria	Complimentary
Journal of Biological Chemistry	Subscription
Journal of Board of Agriculture (English)	Complimentary
Journal of the College of Agriculture, Tokyo	Complimentary
Journal of the Department of Agriculture of South Australia	Complimentary
Journal of the Department of Agriculture of Victoria	Complimentary
Journal of the New Zealand Department of Agriculture	Complimentary
Journal of Economic Biology	Subscription
Journal of Experimental Medicine	Subscription
Journal of Experimental Zoology	Subscription
Journal of Genetics	Subscription
Journal of Hygiene	Subscription
Journal of Heredity	Subscription
Journal of Home Economics	Subscription
Journal of Industrial and Engineering Chemistry	Subscription
Journal of Physiology	Subscription
Just's Botanischer Jahresbericht	Subscription
Kimball's Dairy Farmer	Complimentary
Konigleichen Bayerische Akademie der Wissenschaften: Sitzungsberichte der Math.— Phys. Classe	Subscription
Land, The	Complimentary
Lanswirtschaft-Historische Blätter	Complimentary
Landwirtschaftliche Jahrbucher	Subscription
Landwirtschaftlichen Versuchs-Stationen	Subscription
Lewiston Orchards Life	Complimentary
Live Stock and Dairy Journal	Complimentary
Live Stock Report	Complimentary
Long Island Democrat	Complimentary
Maandblad der Nederlandsche Pomologische Veeriniging	Complimentary
Market Growers' Journal	Complimentary
Memoirs of the Department of Agriculture in India	Complimentary
Metropolitan and Rural Home	Complimentary
Michigan Farmer	Complimentary
Milchwirtschaftliches Zentralblatt	Subscription
Minnesota and Dakota Farmer	Complimentary
Mirror and Farmer	Complimentary
Modern Farming	Complimentary
Monthly Bulletin, International Institute of Agriculture	Complimentary
Monthly Bulletin of the N. Y. State Department of Health	Complimentary
Monthly Weather Review	Complimentary
Mycologia	Subscription

Mycologisches Centralblatt	Subscription
National Nurseryman	Complimentary
National Farmer and Stock Grower	Complimentary
National Stockman and Farmer	Complimentary
Naturaliste Canadienne	Complimentary
Nebraska Farmer	Complimentary
New Education	Complimentary
New England Farmer	Complimentary
New York Academy of Science, Annals and Transactions	Subscription
New York Botanical Garden, Bulletin	Complimentary
New York Entomological Society, Journal	Subscription
New York Farmer	Complimentary
New York Fruit and Produce News	Complimentary
New Zealand Dairyman	Complimentary
North American Horticulturist	Complimentary
North Fort Worth Sunday News	Complimentary
Northwest Pacific Farmer	Complimentary
Nut Grower	Complimentary
Ohio Farmer	Complimentary
Ohio Naturalist	Subscription
Oklahoma Farm Journal	Complimentary
Outdoor World and Recreation	Complimentary
Pacific Coast Fanciers' Monthly	Subscription
Pacific Northwest	Complimentary
Pacific Fruit World	Complimentary
Parasitology	Subscription
Pennsylvania Farmer	Complimentary
Photo-Miniature	Subscription
Phytopathology	Subscription
Popular Agriculturist	Complimentary
Poultry	Complimentary
Poultry Herald	Subscription
Poultry Item	Complimentary
Poultry Keeper	Complimentary
Poultry Monthly	Complimentary
Power and Engineer	Subscription
Practical Farmer	Complimentary
Praktische Blaetter	Subscription
Profitable Breeding and Farming	Complimentary
Progressive Farmer	Complimentary
Profitable Farming	Complimentary
Psyche	Subscription
Quarterly Journal	Complimentary
Rabenhorst's Kryptogamen-Flora	Subscription
Reliable Poultry Journal	Subscription
Republic	Complimentary

Review of Applied Entomology	Subscription
Revista Industrial y Agricola de Tucuman	Complimentary
Revue de Viticulture (For Vineyard Laboratory, Fredonia, N. Y.)	Subscription
Revue Generale de Botanique	Subscription
Revue Generale du Lait	Subscription
Revue Horticole	Subscription
Riqueza Agricola	Complimentary
Rochester Academy of Science, Proceedings	Complimentary
Royal Agricultural Society Journal	Subscription
Royal Botanic Gardens, Edinburgh, Notes	Complimentary
Royal Horticultural Society Journal	Complimentary
Rural Life	Complimentary
Rural New Yorker	Subscription
Salt Lake Herald	Complimentary
Saint Louis Academy of Science, Transactions	Complimentary
Sanitary Inspector	Complimentary
Science	Subscription
Scientific American	Subscription
Scientific Roll, Bacteria	Subscription
Skaneateles Democrat	Complimentary
Smallholder, The	Complimentary
Societe Entomologique Belgique, Annales	Complimentary
Societe Entomologique de France, Bulletin	Complimentary
Societe Mycologique de France, Bulletin	Subscription
Southern Planter	Complimentary
Southern Farm Magazine	Complimentary
Southwestern Farmer and American Horticulturist	Complimentary
Southwestern Farmer and Breeder	Complimentary
Southwestern Stockman, Farmer and Feeder	Complimentary
Stazione Sperimentale Agrarie Italiane	Complimentary
Student Farmer, The	Complimentary
Successful Farming	Complimentary
Suffolk Herald	Complimentary
Texas Stockman and Farmer	Complimentary
Torrey Botanical Club, Bulletins and Memoirs	Subscription
Transvaal Agricultural Journal	Complimentary
Trucker and Farmer	Complimentary
Utica Semi-Weekly Press	Complimentary
Valley Farmer	Complimentary
Wallace's Farmer	Complimentary
Weekly Enquirer (Cincinnati)	Complimentary
West Indian Bulletin	Complimentary
West Virginia Farm Review	Complimentary
Western Fruit-Grower	Complimentary
Western Plowman	Complimentary

Wilson Bulletin	Complimentary
Wisconsin Natural History Society, Bulletin	Complimentary
Zeitschrift fuer Analytische Chemie	Subscription
Zeitschrift fuer Biologie	Subscription
Zeitschrift fuer Botanik	Subscription
Zeitschrift fuer Hygiene und Infektionskrankheiten	Subscription
Zeitschrift fuer Induktive Abstammungs- und Vererbungslehre	Subscription
Zeitschrift fuer Pflanzenkrankheiten	Subscription
Zeitschrift fuer Pflanzenzuchtung	Subscription
Zeitschrift fuer Physiologische Chemie	Subscription
Zeitschrift fuer Wissenschaftliche Insektenbiologie	Subscription
Zentralblatt fuer Biochemie und Biophysik	Subscription
Zoological Record	Subscription
Zoologischer Anzeiger	Subscription

METEOROLOGICAL RECORDS FOR 1914.

METEOROLOGICAL RECORDS FOR 1914.

READING OF THE STANDARD AIR THERMOMETER.

DATE.	JANUARY.			FEBRUARY.			MARCH.			APRIL.			MAY.			JUNE.		
	7 A. M.	12 M.	5 P. M	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.
1.	4.	21.	17.	30.	33.	31.	32.	33.	24.	40.	46.	39.	40.	51.	55.	65.	70.	71.
2.	16.	22.	26.	25.	28.	29.	12.	15.	20.	35.	35.	36.	41.	56.	59.	55.	65.	70.
3.	33.	34.	32.	37.	50.	45.	20.	26.	28.	30.	29.	30.	52.	64.	66.	64.	74.	75.
4.	30.	33.	31.	36.	31.	30.	26.	32.	31.	26.	31.	36.	55.	66.	75.	57.	64.	56.
5.	24.	26.	21.	22.	26.	23.	16.	34.	32.	27.	34.	33.	57.	63.	59.	53.	61.	64.
6.	21.	27.	25.	14.	27.	32.	25.	31.	32.	29.	34.	34.	51.	61.	65.	59.	67.	70.
7.	32.	35.	33.	37.	35.	35.	29.	33.	32.	33.	42.	43.	56.	65.	61.	63.	82.	77.
8.	31.	35.	37.	17.	19.	17.	25.	30.	27.	34.	33.	33.	55.	69.	61.	76.	85.	85.
9.	37.	38.	39.	5.	4.	16.	19.	24.	23.	25.	31.	32.	56.	67.	69.	67.	76.	80.
10.	17.	25.	23.	13.	15.	10.	22.	26.	26.	32.	47.	48.	57.	65.	68.	78.	85.	84.
11.	11.	18.	21.	—2.	2.	0.	17.	25.	22.	38.	46.	39.	54.	57.	50.	73.	63.	83.
12.	19.	13.	6.	—8.	—4.	—3.	8.	31.	29.	38.	48.	39.	48.	46.	45.	72.	74.	75.
13.	—5.	8.	8.	—12.	6.	9.	22.	32.	35.	26.	33.	38.	44.	50.	49.	61.	74.	74.
14.	—6.	6.	19.	10.	18.	15.	25.	40.	40.	35.	57.	63.	44.	60.	60.	60.	68.	70.
15.	22.	23.	29.	7.	10.	12.	35.	39.	38.	44.	56.	52.	47.	57.	58.	65.	72.	66.
16.	32.	36.	37.	9.	13.	16.	39.	46.	47.	35.	38.	35.	52.	63.	58.	53.	62.	63.
17.	26.	25.	23.	7.	17.	18.	33.	45.	41.	43.	52.	62.	58.	70.	71.	55.	72.	74.
18.	13.	19.	17.	5.	26.	25.	35.	33.	33.	44.	68.	79.	55.	75.	77.	63.	77.	80.
19.	23.	29.	33.	19.	25.	23.	17.	21.	22.	64.	80.	60.	58.	75.	79.	66.	76.	59.
20.	33.	33.	28.	5.	15.	10.	12.	17.	16.	51.	53.	45.	61.	80.	80.	48.	57.	67.
21.	28.	23.	15.	1.	17.	15.	13.	26	29.	35.	41.	43.	61.	83.	81.	60.	67.	62.
22.	13.	24.	21.	29.	19.	16.	24.	35.	33.	52.	55.	53.	66.	84.	65.	58.	65.	71.
23.	22.	33.	38.	—2.	3.	5.	28.	35.	36.	35.	45.	48.	53.	57.	63.	70.	82.	85.
24.	38.	40.	35.	—12.	9.	7.	28.	37.	42.	42.	54.	57.	55.	64.	67.	77.	86.	90.
25.	13.	15.	16.	3.	22.	27.	35.	47.	47.	50.	46.	46.	64.	76.	78.	77.	83.	83.
26.	18.	32.	32.	3.	37.	37.	44.	59.	58.	46.	50.	54.	76.	82.	86.	65.	76.	80.
27.	38.	40.	40.	29.	39.	41.	56.	52.	39.	45.	53.	55.	75.	90.	70.	66.	73.	62.
28.	37.	44.	36.	27.	41.	43.	35.	37.	39.	46.	65.	72.	63.	77.	78.	67.	83.	75.
29.	42.	48.	49.	......	......	......	39.	50.	50.	47.	46.	39.	62.	75.	80.	63.	65.	61.
30.	36.	34.	33.	......	......	......	39.	40.	37.	35.	47.	52.	69.	72.	73.	55.	71.	76.
31.	28.	33.	36.	......	......	......	37.	49.	53.	......	......	......	67.	78.	78.	......	......	......
Averages....	23.4	28.1	27.7	12.6	20.9	20.9	27.3	34.8	34.2	38.7	46.5	46.5	56.5	67.7	67.2	63.7	72.5	72.9

Reading of the Standard Air Thermometer — (*Concluded*).

DATE.	July.			August.			September.			October.			November.			December.		
	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.
1	61.	68.	64.	65.	81.	83.	70.	81.	78.	48.	59.	55.	47.	67.	60.	53.	52.	55.
2	62.	67.	69.	71.	83.	78.	72.	87.	74.	41.	63.	64.	52.	47.	43.	52.	59.	58.
3	65.	72.	76.	60.	70.	69.	65.	74.	72.	48.	72.	68.	38.	48.	57.	44.	41.	38.
4	64.	79.	80.	63.	71.	75.	60.	63.	62.	55.	68.	70.	48.	61.	51.	31.	36.	34.
5	69.	82.	82.	64.	79.	81.	57.	67.	71.	57.	75.	75.	43.	47.	43.	41.	38.	35.
6	68.	81.	82.	68.	79.	79.	59.	65.	69.	53.	66.	55.	38.	42.	41.	27.	33.	34.
7	68.	79.	81.	75.	85.	84.	66.	65.	61.	50.	60.	60.	35.	45.	52.	28.	34.	23.
8	72.	88.	81.	72.	85.	87.	51.	58.	60.	54.	72.	74.	42.	41.	35.	31.	32.	32.
9	70.	86.	88.	70.	89.	90.	48.	55.	58.	79.	77.	73.	32.	35.	32.	27.	31.	29.
10	72.	87.	86.	75.	85.	75.	51.	60.	61.	65.	78.	73.	22.	42.	44.	30.	33.	31.
11	72.	85.	89.	71.	74.	73.	43.	53.	56.	65.	70.	65.	41.	44.	38.	28.	29.	26.
12	74.	87.	82.	60.	68.	67.	48.	64.	61.	53.	62.	66.	34.	41.	37.	23.	32.	29.
13	70.	83.	79.	63.	78.	78.	54.	68.	68.	42.	48.	46.	43.	51.	44.	23.	27.	28.
14	70.	70.	73.	65.	67.	72.	55.	69.	69.	44.	54.	51.	30.	40.	39.	29.	20.	12.
15	72.	81.	84.	64.	75.	73.	56.	69.	73.	51.	59.	65.	41.	45.	48.	8.	16.	15.
16	75.	87.	87.	63.	76.	77.	56.	73.	75.	59.	64.	65.	41.	37.	31.	10.	20.	17.
17	76.	75.	73.	65.	75.	78.	57.	75.	77.	64.	68.	63.	25.	30.	26.	4.	23.	16.
18	70.	80.	78.	66.	72.	75.	56.	80.	75.	52.	57.	58.	20.	28.	28.	9.	19.	17.
19	60.	71.	73.	71.	78.	74.	62.	77.	75.	54.	56.	56.	27.	26.	37.	26.	30.	35.
20	64.	75.	82.	68.	67.	68.	59.	81.	82.	45.	68.	65.	34.	31.	29.	21.	28.	26.
21	75.	69.	82.	69.	73.	76.	68.	82.	85.	47.	75.	69.	24.	30.	27.	28.	38.	29.
22	64.	78.	82.	66.	77.	79.	66.	85.	87.	53.	61.	51.	31.	30.	27.	20.	21.	18.
23	71.	78.	70.	67.	84.	87.	71.	66.	61.	40.	68.	59.	21.	22.	20.	14.	19.	15.
24	67.	78.	77.	67.	61.	68.	55.	58.	56.	54.	49.	46.	17.	32.	38.	14.	22.	22.
25	65.	83.	84.	60.	68.	67.	52.	58.	56.	35.	52.	50.	39.	48.	49.	5.	20.	6.
26	70.	82.	85.	58.	59.	72.	46.	56.	55.	45.	48.	38.	46.	60.	60.	—5.	12.	5.
27	68.	80.	70.	55.	73.	67.	59.	53.	57.	27.	34.	34.	47.	44.	37.	—6.	16.	23.
28	63.	75.	70.	65.	73.	71.	45.	56.	52.	37.	50.	46.	23.	40.	39.	21.	28.	28.
29	65.	71.	69.	63.	64.	73.	44.	55.	61.	42.	49.	45.	30.	44.	48.	27.	33.	28.
30	52.	72.	75.	64.	73.	75.	54.	60.	57.	39.	41.	41.	48.	51.	53.	37.	35.	25.
31	65.	69.	75.	66.	80.	83.	......	......	......	34.	52.	53.	......	......	......	20.	23.	18.
Averages....	67.7	78.	78.3	65.8	74.9	75.9	56.8	67.1	66.8	49.4	60.5	58.	35.3	41.6	40.4	23.2	29.	26.

READING OF MAXIMUM AND MINIMUM THERMOMETERS FOR 1914.

DATE.	January.		February.		March.		April.		May.		June.	
	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.
1	29.	3.	39.	20.	43.	23.	53.	34.	55.	34.	78.	56.
2	26.	13.	31.	20.	21.	11.	41.	34.	60.	35.	71.	47.
3	35.	25.	52.	25.	30.	19.	36.	24.	68.	37.	76.	59.
4	34.	23.	45.	29.	34.	25.	37.	23.	77.	45.	75.	56.
5	31.	23.	30.	21	38.	16.	36.	26.	75.	54.	65.	46.
6	30.	16.	32.	14.	32.	22.	36.	24.	67.	48.	71.	43.
7	35.	24.	39.	14.	34.	28.	44.	31.	67.	53.	87.	53.
8	37.	30.	35.	15	33.	23.	43.	32.	72.	48.	88.	65.
9	40.	35.	17.	4.	27.	17.	34.	22.	71.	51.	86.	66.
10	40.	13.	16.	9.	28.	20.	49.	27.	69.	46.	86.	66.
11	23.	11.	10.	—4.	26.	12.	49.	32.	68.	49.	85.	62.
12	21	6.	9.	—9.	31.	7.	52.	31.	52.	43.	83.	64.
13	6.	—9.	9.	—14.	36.	14.	40.	22.	51.	42.	76.	56.
14	11.	—9.	19.	9.	42.	15.	65.	24.	64.	43.	74.	50.
15	29.	8.	15.	5.	45.	34.	63.	40.	60.	41.	73.	54.
16	39.	29.	18.	7.	53.	32.	52.	35.	66.	38.	66.	48.
17	37.	23.	18.	5.	48.	33.	63.	34.	72.	45.	76.	46.
18	23.	5.	26.	3.	41.	32.	79.	39.	78.	44.	82.	52.
19	33.	10.	29.	17.	33.	17.	82.	59.	82.	45.	80	58.
20	34.	32.	23.	5.	22.	11.	60.	45.	84.	50.	67.	39.
21	37.	14.	20.	1.	32.	10.	45.	33.	85.	49.	69.	50.
22	26.	8.	30.	11.	36.	19.	54.	40.	84.	56.	75.	55.
23	38.	16.	16.	—3.	39.	26.	53.	31.	65.	52.	86.	63.
24	41.	25.	10.	—14.	43.	27.	59.	29.	70.	43.	90.	66.
25	35.	11.	29.	0.	51.	27.	57.	44.	81.	57.	90.	66.
26	34.	5.	40.	3.	65.	38.	55.	41.	90.	64.	83.	58.
27	40.	30.	43.	27.	58.	38.	56.	44.	90.	65.	80.	60.
28	45.	35.	49.	22.	39.	34.	75.	38.	78.	60.	84.	61.
29	51.	35.	......	......	55.	36.	72.	38.	81.	48.	75.	61.
30	49.	32.	......	......	50.	37.	52.	34.	80.	61.	77.	53.
31	36.	26.	......	......	53.	34.	......	......	79.	51.	......	......
Averages	33.1	17.7	26.8	8.6	39.5	23.8	53.1	33.7	72.	48.3	78.5	56.

Reading of Maximum and Minimum Thermometers for 1914 — (*Concluded*).

DATE.	July.		August.		September.		October.		November.		December.	
	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.
1	76.	50.	85.	59.	83.	64.	62.	42.	69.	44.	58.	51.
2	74.	57.	85.	58.	89.	68.	70.	35.	61.	42.	64.	51.
3	77.	55.	79.	59.	77.	58.	78.	41.	60.	33.	60.	37.
4	83.	50.	77.	57.	72.	56.	74.	47.	62.	30.	39.	31.
5	86.	60.	83.	52.	74.	51.	81.	54.	51.	41.	40.	30.
6	85.	57.	83.	61.	73.	52.	75.	52.	44.	32.	35.	21.
7	82.	65.	92.	65.	70.	61.	64.	47.	54.	33.	35.	28.
8	89.	60.	89.	67.	62.	44.	80.	52.	57.	34.	33.	27.
9	89.	62.	94.	57.	61.	46.	78.	64.	36.	31.	33.	27.
10	88.	63.	91.	70.	66.	43.	84.	61.	57.	22.	33.	28.
11	93.	60.	82.	70.	61.	40.	76.	63.	50.	33.	31.	26.
12	91.	64.	74.	59.	66.	42.	66.	51.	45.	34.	33.	15.
13	86.	68.	81.	50.	72.	40.	66.	41.	51.	28.	30.	20.
14	79.	68.	78.	62.	73.	45.	54.	42.	47.	30.	31.	12.
15	87.	67.	77.	55.	75.	46.	65.	49.	48.	33.	17.	6.
16	89.	69.	81.	55.	81.	48.	66.	57.	55.	31.	20.	7.
17	91.	70.	79.	60.	84.	49.	70.	62.	31.	24.	25.	3.
18	81.	62.	79.	65.	85.	47.	63.	50.	32.	18.	23.	4.
19	78.	55.	80.	63.	82.	49.	61.	49.	42.	26.	35.	16.
20	82.	53.	79.	66.	85.	50.	72.	42.	37.	25.	37.	10.
21	86.	57.	76.	65.	90.	53.	75.	45.	30.	19.	39.	18.
22	83.	52.	83.	60.	92.	61.	69.	52.	33.	26.	29.	18.
23	82.	62.	89.	62.	87.	60.	61.	34.	27.	19.	20.	10.
24	80.	65.	87.	60.	61.	55.	60.	45.	40.	16.	23.	9.
25	85.	61.	72.	48.	62.	48.	61.	32.	51.	22.	22.	9.
26	87.	66.	75.	47.	60.	42.	50.	36.	65.	48.	17.	—6.
27	86.	60.	75.	52.	58.	48.	38.	26.	60.	33.	24.	—6.
28	76.	60.	74.	62.	58.	40.	52.	32.	46.	27.	33.	19.
29	76.	56.	79.	62.	63.	38.	50.	37.	52.	22.	39.	22.
30	77.	52.	78.	60.	61.	52.	45.	37.	53.	47.	43.	25.
31	82.	52.	84.	62.	......	......	59.	30.	......	......	25.	18.
Averages	83.4	59.9	81.3	59.7	72.8	49.9	65.3	45.4	48.2	30.1	33.1	18.9

SUMMARY OF AVERAGES OF MAXIMUM, MINIMUM AND STANDARD AIR THERMOMETERS FOR 1914.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Maximum	33.1	26.8	39.5	53.1	72.	78.5	83.4	81.3	72.8	65.3	48.2	33.1
Minimum	17.7	8.6	23.8	33.7	48.3	56.	59.9	59.7	49.9	45.4	30.1	18.9
Standard 7 A. M	23.4	12.6	27.3	38.7	56.5	63.7	67.7	65.8	56.8	49.4	35.3	23.2
Standard 12 M.	28.1	20.9	34.8	46.5	67.7	72.5	78.	74.9	67.1	60.5	41.6	29.
Standard 5 P. M	27.7	20.9	34.2	46.5	67.2	72.9	78.3	75.9	66.8	58.	40.4	26.

MONTHLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1914 INCLUSIVE.

(Highest and Lowest Record for Each Month in Heavy Type.)

	January.				February.				March.				April.			
	Max.		Min.		Max.		Min.		Max.		Min.		Max.		Min.	
	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.
1883	18.	44.	11.	—9.	17.	48.	24.	—2.	19.	61.	9.	2.	16.	75.	1.	19.
1884	14.	42.	26.	—13.	7.	55.	29.	—3.	30.	54.	1.	—4.	28.	74.	1.	23.
1885	1.	61.	29.	—6.	10.	38.	11.	—11.5	28.	48.	13.	**—11.**	24.	84.5	10.	20.5
1886	5.	52.5	13.	—18.7	9.	50.	27.	—11.	16.	58.	2.	—2.5	24.	80.5	4.	22.
1887	24.	50.7	19.	—8.	9.	54.2	27.	—4.	3.	51.7	1 & 5	8.7	11.	75.7	1.	17.2
1888	2.	43.2	23.	—6.	21.	49.	10.	—7.	28.	57.	13.	0.	29.	82.5	8.	19.
1889	18.	55.	20.	5.	23.	42.	4 & 24	—7.	28.	61.8	30.	18.5	20.	84.	1.	26.
1890	6.	67.	29.	9.	5.	**64.5**	11&21	9.5	13.	62.	8.	2.	13.	78.8	1 & 19	23.
1891	3.	46.	17.	4.	26.	56.8	15.	2.5	12.	57.	2.	4.5	28.	81.4	7.	21.
1892	3.	48.	10.	—5.	15.	44.	6.	2.8	27.	52.2	4.	6.	6.	78.	17.	25.5
1893	29.	46.	11.	—6.	15.	47.4	5.	—1.	24.	54.	5.	9.	13.	75.3	26.2	25.
1894	5.	59.	13.	11.	20.	47.6	27.	—8.5	18.	73.	26.	15.	21.	71.3	2.	20.
1895*	7.	45.	19.	4.	25.	46.	8.	—14.	25.	52.	5 & 16	12.	30.	80.	3.	28.
1896	30.	44.	6.	—16.5	29.	49.	17.	—21.	31.	56.5	24.	—2.	17.	**87.**	4 & 5	19.
1897	5.	58.	20.	—3.5	18.	49.5	1 & 27	5.5	21.	64.	1.	—1.	26.	82.	20.	19.
1898	13.	57.	30&31	—4.	12.	56.5	2 & 3	—2.	11.	†65.	2.	17.5	14&18	69.	69.	18.
1899	5.	59.	12.	—4.	21.	52.5	11.	—8.	73.	63.	21.	13.	30.	82.	3.	23.
1900	23.	56.	1.	2.	14.	57.	27.	0.	10.	46.	12.	—3.	30.	‡73.5	9.	22.
1901	16.	48.	20.	—2.	16.	36.	24.	—2.5	24.	67.	6.	—1.	28.	78.	12.	28.
1902	3.	44.	28.	2.	28.	52.	6.	—3.	12.	66.5	19.	14.	22.	**87.**	5.	25.
1903	3.	48.	9.	—2.	28.	62.5	18.	—4.	19.	78.5	1 & 2	19.	30.	86.	5.	21.
1904	23.	48.	19.	—14.	7.	58.	16.	18.	26.	58.	4.	8.	24.	67.5	14.	**16.**
1905	1.	49.	26.	—2.	20.	45.	5 & 14	—6.	29.	82.	5.	1.	27&28	75.	16.	23.
1906	21.	**71.**	9.	4.	24.	64.	6 & 7	—7.	27.	51.	25.	2.	19.	74.	2.	25.
1907	6.	53.	24.	—18.	2.	47.	12.	—4.	29.	83.	7.	—1.	29.	73.	2.	19.
1908	22.	45.	31.	—9.	15.	53.	2 & 5	—14.	28.	73.	1.	8.	27.	78.	4.	18.
1909	24.	64.	19.	—7.	5.	52.	1.	—1.	10.	52.	5.	5.	19.	75.	11.	12.
1910	2 & 22	45.	5.	—8.	16.	29.	7.	—3.	24.	82.	14&18	17.	4.	84.	7.	27.
1911	27&30	48.	5.	—1.	17.	52.	22.	4.	27.	60.	16.	—1.	29.	80.	3.	18.
1912	18.	44.	14.	—12.	24.	48.	10.	—10.	31.	62.	4.	—1.	6.	78.	4.	19.
1913	17.	57.	13.	8.	20.	65.	10.	—10.	14&15	69.	7 & 8	1.	24.	84.	20.	24.
1914	29.	51.	13&14	—9.	3.	52.	13&24	—14.	26.	65.	12.	7.	19.	82.	9 & 13	22.

* Data from record kept by Mr. Edgar Parker for the year 1895; Station record not available.
† Maximum for first eleven days only. Record incomplete.
‡ Thermometers broken. Record not taken from April 19th to 24th inclusive.

MONTHLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1914 INCLUSIVE — (*Continued*).

(Highest and Lowest Record for Each Month in Heavy Type.)

	MAY.				JUNE.				JULY.				AUGUST.			
	MAX.		MIN.		MAX.		MIN.		MAX.		MIN.		MAX.		MIN.	
	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.
1883	11.	87.	1 & 14	31.	7.	86.5	2.	42.	5.	89.	1.	46.	23.	92.	15.	46.
1884	24.	88.	30.	32.	25.	90.	15.	41.	2.	87.5	15.	50.	20.	95.	25.	44.
1885	18.	81.7	3.	27.5	14.	86.5	23.	41.5	18.	90.5	12.	46.5	1.	89.	28.	45.
1886	23.	79.5	17&18	37.2	14.	86.2	1.	42.2	7.	95.	1.	45.2	30.	91.5	6.	47.7
1887	23.	88.2	14.	37.5	17.	89.2	15.	47.7	3.	95.5	11.	58.7	3.	88.5	8.	46.
1888	13.	79.8	3.	29.	23.	94.1	4.	40.	5.	89.8	16.	47.	9.	92.6	23.	48.3
1889	18.	91.8	29.	32.	22.	85.	5.	46.	11.	90.7	6.	50.5	31.	86.7	16&17	50.3
1890	4.	80.7	2.	30.	30.	85.6	8.	44.8	9.	94.5	24.	46.5	4.	96.2	24.	46.0
1891	11.	85.5	4.	29.5	16.	95.	6.	40.	14.	92.	31.	46.	12.	92.	29.	46.5
1892	31.	78.	9.	34.2	14.	92.	11.	45.8	29.	96.3	2.	46.4	10.	95.5	28.	49.
1893	25.	88.	9.	35.	21.	94.	1.	44.	26.	95.5	24.	48.4	11.	94.5	13.	49.
1894	2.	85.4	14.	32.6	23.	91.6	6.	39.	21.	97.	10.	49.6	25.	93.	27.	45.3
1895*	31.	**92.**	13&21	36.	3.	**96.**	7.	54.	8.	94.	11.	52.	11.	88.	22.	44.
1896	11.	87.5	7 & 20	40.	21.	89.	3.	41.	3.	94.	18.	49.	6 & 7	96.	29.	44.
1897	24.	80.	8.	32.5	24&25	87.5	2.	42.	11.	97.	15.	57.	15.	87.5	21.	46.
1898	29.	79.	6.	34.	9.	90.	16.	40.	4.	96.5	12.	**40.**	24.	90.5	28.	47.
1899	2.	87.5	15.	32.5	6 & 24	93.	11.	41.5	4.	97.5	1.	50.	20.	97.5	15.	44.5
1900	15&16	88.5	7.	27.	25.	93.	10.	45.	17.	96.	1.	50.	11.	97.	2.	51.
1901	23.	78.	16.	36.	27, 28 & 29	95.5	2.	42.	1.	97.5	20.	54.5	22.	90.	5.	52.
1902	22.	90.	11.	26.	3.	85.	6.	38.	14&27	90.	1.	53.	31.	90.	13.	47.
1903	19.	89.	2.	**24.**	30.	86.5	1.	39.	9.	94.	15.	50.	18.	85.5	8 & 14	45.
1904	25.	88.	12.	31.5	5–24 & 25.	89.	12&17	45.	19.	93.	3.	49.	25.	89.5	19.	45.
1905	3.	82.	2.	29.5	19.	90.	1.	40.	18.	92.	22.	48.5	10.	93.	27.	**41.**
1906	24.	88.5	11&21	30.	8.	92.	12.	**37.**	20–22 & 23	89.	25.	50.	5.	93.	16.	47.
1907	14.	85.	2–11 & 12	28.	18.	94.	3.	41.	16.	90.	4.	46.	12.	96.5	19.	41.5
1908	29.	90.	1–4&5	31.	19.	92.	12.	43.	6–11 & 30	94.	9.	52.	4.	95.	25.	46.
1909	31.	78.	2 & 3	33.	28.	90.	8.	43.	15.	92.	4.	42.	8.	**98.**	31.	42.
1910	20.	79.	16.	31.5	22.	89.9	4.	36.	9.	96.5	5.	50.	3 & 15	90.	27.	**44.**
1911	22.	97.	3.	27.	11.	90.5	17.	46.	5.	**105.0**	25–26 & 27	50.	8.	94.5	30.	47.
1912	24.	88.	14.	34.	1.	89.	8.	40.	8 & 10	95.	1.	41.	14.	92.	17.	44.
1913	4.	91.	11.	30.	30.	92.	9.	37.	1 & 4	95.	12.	50.	17.	**98.**	25&26	44.
1914	26&27	90.	1.	34.	24&25	90.	20.	39.	11.	93.	4.	50.	9.	94.	26.	47.

* Data from record kept by Mr. Edgar Parker for the year 1895; Station record not available.

MONTHLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1914 INCLUSIVE — (*Concluded*).

(Highest and Lowest Record for Each Month in Heavy Type.)

	SEPTEMBER.				OCTOBER.				NOVEMBER.				DECEMBER.			
	MAX.		MIN.		MAX.		MIN.		MAX.		MIN.		MAX.		MIN.	
	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.
1883	17.	80.	11.	37.	11.	78.	17&18	25.	22.	70.	17.	13.	9 & 14	56.	23.	—7.5
1884	5.	94.	14.	36.	5.	84.2	27.	23.	11.	62.	25.	15.	31.	55.5	20.	**—15.5**
1885	27.	83.7	24.	40.	1.	79.	13.	25.	8 & 13	68.	28.	18.	24.	53.	9.	4.
1886	11.	89.5	22.	49.	10.	76.7	17.	27.5	3.	68.2	28.	17.	11&25	46.	6.	—6.
1887	22.	81.7	27.	37.2	9.	78.5	31.	21.2	28.	68.	30.	15.	12.	54.7	2.	—3.
1888	1 & 10	83.	7.	40.	6.	62.7	22.	29.	1 & 3	73.	23.	8.	27.	53.	22.	4.
1889	4.	84.	22 & 23&29	40.	2.	68.7	24.	21.2	4.	61.7	17.	17.8	25.	60.5	4 & 5	8.
1890	8.	83.6	25.	35.5	5.	69.8	31.	32.	8.	65.4	28.	17.	1.	46.2	20.	3.
1891	26.	92.8	30.	43.	4.	89.4	12&25	27.	1.	68.	29.	12.	5.	57.7	18.	7.
1892	26.	88.	20.	39.	1.	82.	2.	33.1	19.	60.	24.	18.	9.	49.2	27.	—3.7
1893	5.	80.	26.	37.4	13.	76.	31.	25.	3.	62.	27.	19.	26.	62.	14.	1.5
1894	4.	90.	26.	33.	1.	76.5	15.	33.	3.	65.	29.	12.	17.	59.	29.	—0.2
1895*	4.	94.	15&30	42.	2.	72.	30.	28.	7.	68.	21.	19.	20&21	62.	13.	—2.
1896	12.	95.	23.	36.	30.	77.5	10&19	29.	19.	70.	21.	19.5	14.	58.	28.	2.
1897	11.	98.	21.	37.5	16.	88.	10&18	30.	6.	65.	24.	16.5	12.	61.5	24.	2.
1898	4.	94.	21.	40.5	1.	85.5	28.	31.	5.	63.	28.	16.	31.	54.	14.	3.
1899	4.	92.	15&30	**30.**	15.	86.	3.	26.	19.	60.	14.	25.	12.	60.	31.	—1.
1900	12.	95.	19.	37.	6 & 7	**89.**	20.	28.	22.	70.	17.	19.	4.	55.	10&14	4.
1901	6.	89.	26.	36.	10&11	74.	28.	28.	1.	65.	27.	13.	14.	62.	18.	—1.
1902	1.	90.	15.	38.	19.	74.	10 & 22&30	29.	14.	73.	29.	22.	2.	52.	9.	—5.
1903	14.	90.	29.	35.	1.	73.	25&27	28.	4.	70.	26&27	12.	3.	46.	19.	—4.
1904	3.	88.	23.	33.	10.	81.	31.	22.	3.	65.	29.	9.	23.	53.	16.	—2.
1905	30.	88.5	26.	36.	1.	85.	26.	**20.5**	12.	61.	14.	11.	29.	52.5	15.	1.
1906	18.	91.5	25.	38.	5.	79.5	13&31	30.	19.	62.	30.	16.	6.	52.	8.	—1.
1907	20.	90.	27.	39.	†3.	80.	31.	24.	1.	59.	12&16	22.	30.	57.	22.	13.5
1908	10.	92.	30.	37.	18.	83.	21.	27.	26.	68.	5.	18.	1.	64.	23.	3.
1909	14.	93.	2 & 6	35.	9.	82.5	29&30	27.	11.	75.	24.	21.	6.	45.	30.	1.
1910	6.	87.	15&23	40.	6.	81.	30.	26.	1.	59.	23.	21.	29.	41.	31.	—2.5
1911	2.	87.	14.	35.	4.	78.	3.	33.	11.	68.	13.	18.	9.	**67.9**	4 & 30	13.
1912	6 & 10	95.	30.	34.	6.	83.	16.	31.	6 & 7	69.	28.	20.	6.	65.	9 & 12	12.
1913	3.	95.	15.	28.	6.	81.	31.	29.	22.	73.	27.	22.	7.	56.	28.	6.
1914	22.	92.	29.	38.	10.	84.	27.	26.	1.	69.	24.	16.	2.	64.	26&27	—6.

* Data from record kept by Mr. Edgar Parker for the year 1895; Station record not available.
† Thermometer broken on the 27th, 28th, and 29th of October.

YEARLY MAXIMUM AND MINIMUM TEMPERATURES FROM 1883 TO 1914 INCLUSIVE.

(Highest and Lowest Record for THE TIME in Heavy Type.)

	Maximum for Each Year.		Minimum for Each Year.	
	Date.	Temp.	Date.	Temp.
1883	Aug. 23	92.	Jan. 11	— 9.
1884	Aug. 20	95.	Dec. 20	—15.5
1885	July 18	90.5	Feb. 11	—11.5
1886	July 7	95.	Jan. 13	—18.7
1887	July 3	95.5	Jan. 19	— 8.
1888	June 23	94.1	Feb. 10	— 7.
1889	May 18	91.8	Feb. 4 and 24	— 7.
1890	Aug. 4	96.2	Mar. 8	2.
1891	June 16	95.	Feb. 15	2.5
1892	July 29	96.3	Jan. 10	— 5.
1893	July 26	95.5	Jan. 11	— 6.
1894	July 21	97.	Feb. 27	— 8.5
1895*	June 3	96.	Feb. 8	—14.
1896	Aug. 6 and 7	96.	Feb. 17	**—21.**
1897	Sept. 11	98.	Jan. 20	— 3.5
1898	July 4	96.5	Jan. 30 and 31	— 4.
1899	July 4 and Aug. 20	97.5	Feb. 11	— 8.
1900	Aug. 1	97.	Feb. 27	0.
1901	July 1	97.5	Feb. 24	2.5
1902	May 24, July 14 and 27, August 31 and Sept. 1	90.	Dec. 9	— 5.
1903	July 9	94.	Feb. 18 and Dec. 19	— 4.
1904	July 19	93.	Feb. 16	—18.
1905	Aug. 10	93.	Feb. 5 and 14	— 6.
1906	Aug. 5	93.	Feb. 6 and 7	— 7.
1907	Aug. 12	96.5	Jan. 24	—18.
1908	Aug. 4	95.	Jan. 2 and 5	—14.
1909	Aug. 8	98.	Jan. 19	— 7.
1910	July 9	96.5	Jan. 5	— 8.
1911	July. 5	**105.**	Jan. 5	— 1.
1912	Sept. 6	95.	Jan. 14	—12.
1913	Aug. 17	98.	Feb. 10	—10.
1914	Aug. 9	94.	Feb. 13 and 24	—14.

*Data from record kept by Mr. Edgar Parker; Station record not available.

Average Monthly and Yearly Temperatures Since 1882.

YEAR.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Yearly averages.
1883	17.4	22.3	23.6	43.3	52.0	66.6	67.4	65.6	56.3	46.6	39.1	27.5	44.0
1884	17.6	28.3	29.5	40.7	54.3	67.1	66.5	69.9	65.2	50.5	36.5	27.2	46.1
1885	20.6	11.4	18.8	41.2	54.3	63.6	69.7	65.0	58.3	49.2	39.3	27.8	43.3
1886	19.6	22.9	30.2	48.1	55.7	64.0	68.0	67.5	61.8	49.6	36.8	22.2	45.5
1887	20.2	23.2	26.3	41.1	62.5	65.7	75.6	66.5	57.7	47.0	37.6	27.6	45.9
1888	16.4	22.8	24.6	40.8	54.3	66.5	66.8	68.0	62.2	43.9	39.4	29.3	44.6
1889	29.1	18.1	33.9	45.1	58.4	65.3	70.2	66.0	60.5	44.0	40.3	35.2	47.2
1890	31.2	30.9	28.8	44.2	52.3	67.1	69.5	67.7	60.1	49.3	37.6	21.4	46.7
1891	25.9	28.3	30.8	45.3	52.0	66.4	66.4	68.5	66.2	48.3	38.4	35.5	47.7
1892	21.4	25.9	26.5	43.5	52.8	68.6	70.2	69.4	61.2	50.0	35.9	25.2	45.9
1893	15.5	20.6	29.5	41.1	54.1	68.2	69.8	68.8	58.0	52.0	38.2	27.5	45.3
1894	29.7	20.6	38.9	44.1	55.5	67.8	74.2	66.8	64.9	52.7	36.0	31.5	48.6
1895	21.8	16.9	26.9	44.4	59.0	......	......	71.2	61.7	45.4	39.6	31.4	......
1896	22.4	24.1	24.4	49.3	62.0	65.9	71.4	70.0	60.2	56.5	42.9	27.1	48.0
1897	23.2	26.1	33.8	45.0	55.4	62.3	73.6	67.6	62.3	52.6	39.7	29.2	47.6
1898	26.2	26.8	......	43.2	57.0	67.7	74.2	71.0	65.9	52.1	37.9	27.9	......
1899	22.1	20.4	30.4	46.6	57.6	69.5	71.2	71.6	60.6	53.5	38.9	30.0	47.7
1900	26.0	22.6	23.6	43.5	56.7	68.4	72.6	74.1	66.1	57.9	41.1	28.7	48.4
1901	26.1	18.5	32.2	46.5	56.9	68.9	76.6	71.0	64.0	51.4	34.3	27.7	47.9
1902	23.2	22.2	39.5	46.6	56.1	63.2	71.2	67.6	53.6	43.1	46.3	25.7	47.4
1903	25.7	28.1	42.2	45.9	60.4	63.2	70.8	65.5	64.4	52.5	36.2	23.3	48.2
1904	18.9	23.1	30.9	41.4	60.3	67.8	70.0	68.2	61.9	48.4	36.9	22.5	45.9
1905	19.8	18.9	33.1	44.8	57.5	66.4	71.8	68.7	63.7	52.4	37.6	32.0	47.2
1906	32.5	26.1	27.6	46.4	57.5	68.2	71.4	72.8	67.3	51.2	37.9	26.1	48.8
1907	24.9	19.5	38.1	40.2	51.3	64.0	71.2	68.4	64.4	47.9	38.7	31.8	46.7
1908	25.9	21.3	34.6	44.8	59.2	68.8	73.4	68.8	67.0	52.9	40.0	29.2	48.8
1909	27.7	28.6	31.0	44.3	57.9	67.2	69.6	70.0	63.5	47.7	44.5	25.7	48.1
1910	25.1	22.1	42.1	50.1	54.9	65.2	73.1	69.0	63.2	53.1	35.7	21.5	47.9
1911	24.9	26.6	30.9	44.8	64.9	67.5	74.4	70.9	62.8	50.7	36.6	35.1	49.4
1912	15.9	21.6	28.2	45.1	58.9	64.3	73.2	68.6	68.4	53.5	42.5	33.9	47.8
1913	32.7	18.8	36.9	48.3	56.9	66.8	72.1	70.0	61.3	54.0	44.5	33.6	49.7
1914	25.4	17.7	31.7	43.4	60.2	67.3	59.9	70.5	61.4	55.4	39.2	26.0	46.5
Monthly averages	23.6	22.7	31.0	44.5	56.8	66.4	70.8	68.9	62.4	50.5	38.9	28.3	47.1

PRECIPITATION BY RAINFALL ONLY BY MONTHS SINCE 1882.

YEAR.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
1882	......	......	......	......	......	3.69	2.42	2.37	1.25	0.62	1.22	0.55	....
1883	0.48	1.44	0.88	1.58	4.45	4.12	2.98	3.47	2.12	2.10	1.54	0.73	25.89
1884	1.83	2.01	2.54	0.83	2.49	2.01	2.33	1.44	3.17	1.67	1.01	0.97	22.30
1885	1.07	0.61	0.12	1.26	1.58	2.49	4.64	5.02	2.11	2.88	1.36	0.76	23.90
1886	1.13	0.95	1.13	4.13	1.92	2.92	4.41	2.86	2.31	1.79	3.48	1.24	27.87
1887	0.18	2.97	0.48	1.37	0.46	2.01	6.37	3.03	0.75	1.74	1.58	1.35	22.29
1888	0.78	1.04	1.43	3.09	2.79	2.88	0.99+	4.02	2.73	3.47	2.02	1.24	20.48
1889	2.99+	0.25	0.66+	3.28	1.21	7.47	4.57	1.98	2.50	3.32	3.44	1.62	32.28
1890	2.16	1.45	2.16	2.20	5.49	4.26	1.07	4.31	5.81	4.54	2.40	......	36.88
1891	1.44	1.57	3.25	1.63	0.49	4.31	3.52	3.16	0.47	2.65	0.74	3.29	27.52
1892	0.57	0.88	0.55	0.67	4.04	3.95	1.89	4.77	1.12	1.34	1.67	0.72	23.17
1893	1.62	3.71	1.94	2.59	4.92	3.08	2.68	5.38	2.68	1.59	1.09	1.56	33.84
1894	2.21	2.71	1.36	2.43	7.03	1.77	1.50	1.22	4.64	3.59	0.43	0.47	29.36
1895	0.96	......	0.29	1.36	2.88	......	......	2.66	0.94	0.72	2.31	2.49	.....
1896	1.19	2.28	0.84	0.41	2.31	3.71	4.12	3.33	4.27	2.26	2.18	0.71	27.61
1897	0.64	0.21	2.12	1.90	2.19	3.16	5.28	1.27	2.36	0.73	2.53	1.39	23.78
1898	1.74	0.33	1.54	2.03	1.90	2.37	1.32	3.60	1.86	3.83	2.03	0.33	22.90
1899	0.37	0.30	1.22	1.12	1.69	1.71	4.15	1.05	2.23	2.69	1.36	1.46	19.35
1900	1.43	2.42	0.02	0.95	1.71	1.45	6.53	1.75	0.91	3.65	6.13	0.78	27.73
1901	0.72	......	2.19	4.43	3.80	2.07	3.97	5.52	2.46	1.35	2.09	3.37	31.97
1902	0.86	0.66	1.94	1.92	2.84	4.33	5.29	2.41	2.88	2.32	0.74	0.74	26.89
1903	1.81	1.11	5.62	2.60	0.23	7.77	4.86	7.21	1.30	4.19	1.63	0.38	38.69
1904	0.80	1.03	2.41	1.67	4.04	3.37	5.73	2.56	3.26	2.06	0.26	1.42	28.61
1905	0.40	0.27	1.09	2.05	2.01	8.78	3.59	5.44	1.90	3.69	1.32	1.84	32.38
1906	1.46	0.53	1.60	2.08	4.24	5.31	2.37	3.68	2.16	3.56	1.40	1.54	29.93
1907	1.89	0.03	1.14	2.42	1.82	2.34	2.86	1.35	2.73	2.48	2.78	1.89	24.73
1908	0.68	1.12	1.24	3.28	3.57	1.96	4.72	1.79	1.66	2.73	0.88	0.43	24.06
1909	0.94	1.68	1.35	3.20	2.83	2.17	2.04	2.21	2.22	1.18	0.56	0.49	20.87
1910	0.87	0.53	0.28	4.56	3.45	1.55	2.39	5.47	3.29	1.73	0.62	0.38	25.12
1911	0.91	0.24	1.07	3.24	1.36	2.51	4.49	3.36	3.21	2.37	1.41	2.08	26.25
1912	0.20	0.95	1.92	3.41	7.27	2.09	4.85	2.21	5.89	1.42	1.48	1.13	32.82
1913	3.88	0.11	4.64	3.40	2.68	3.24	2.03	1.65	2.64	4.03	2.41	0.77	31.48
1914	0.98	0.15	1.28	3.10	4.00	2.69	2.18	6.05	1.62	1.55	1.08	1.13	25.81
Monthly averages	1.22	1.12	1.57	2.32	2.93	3.36	3.50	3.26	2.47	2.42	1.73	1.23	27.31

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